FOOD TECHNOLOGY

PUBLISHED BY THE INSTITUTE OF FOOD TECHNOLOGISTS

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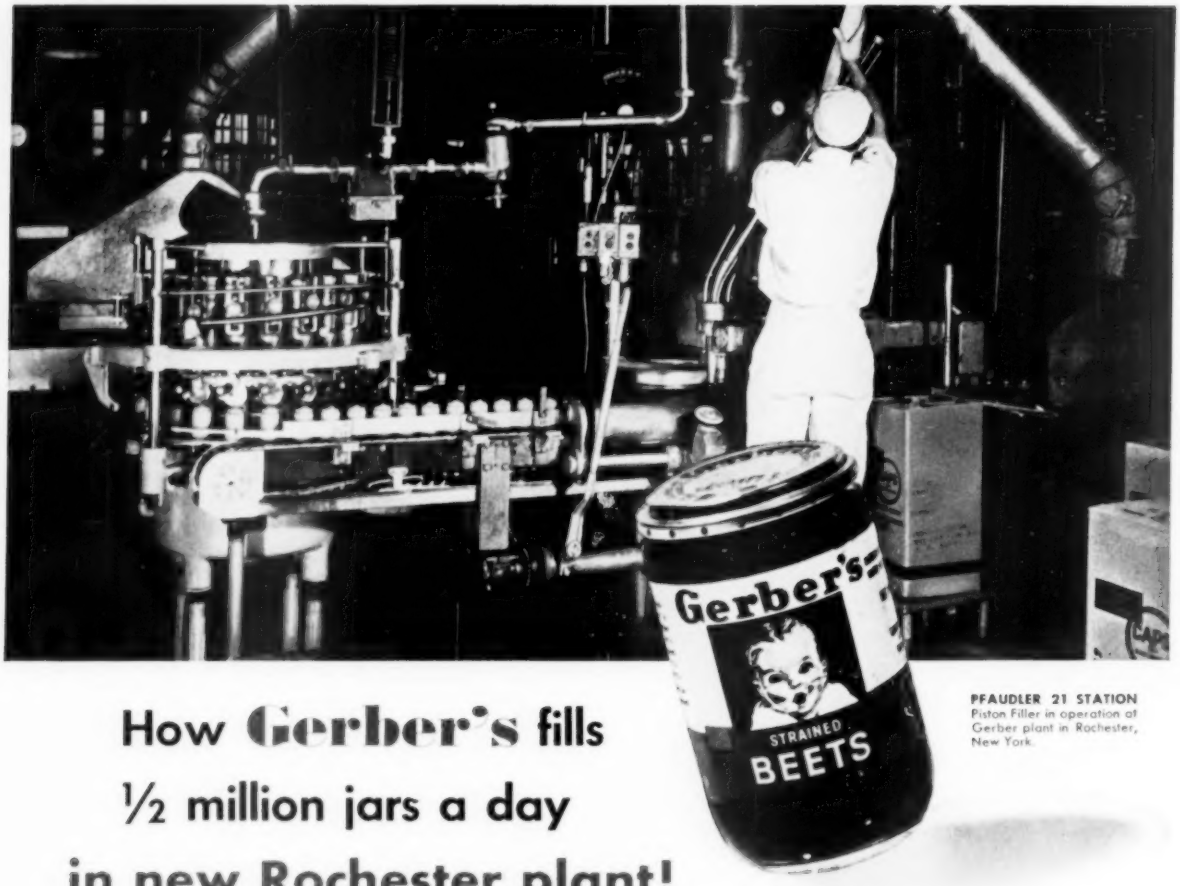

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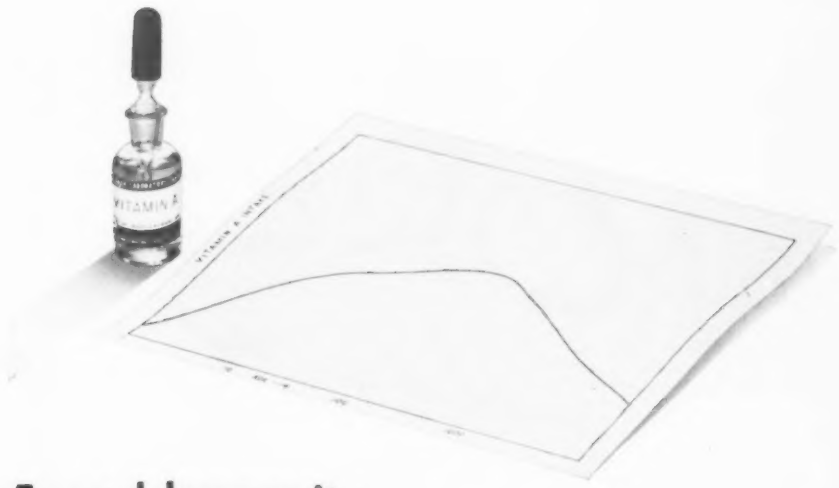

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Food Industry Topics
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New Chapter of IFT History Written in Boston

An outstanding meeting! This was the sentiment of some 1600 registrants foregathered at the Statler in Boston, June 21-25. Credit for the success of the meetings is due the Northeast Section in general—and to Dr. Proctor, J. Avery Dunn, Loren Sjostrom, and many, many others in particular. Even the Boston weather, warmish at the outset, turned in a good performance before the sessions ended. On the final day of the meetings President Proctor turned over the gavel to his successor in office, Dr. Berton S. Clark—who is already hard at work. The new president-elect is Dr. Philip K. Bates and the new treasurer is Dr. Aksel Olsen. Fuller details regarding the new officers and a resume of business conducted at the Executive Council meeting will appear in the August issue.

Masters and Doctors in Food Technology—1953

(Second Installment)

Continuing the roster of winners of advanced degrees in the field of food technology, the following names are added to the list begun in the June issue:

CORNELL UNIVERSITY (ITHACA, NEW YORK)

Name	*Degree*	*Thesis or Dissertation*
(Miss) Sigrun Fridriksdotter	M.S.	A Method for Determining Fat Deterioration in Frozen Herring

IOWA STATE COLLEGE (AMES)

A. A. Kraft	Ph.D.	Storage Changes in Packaged Meats
T. L. Hurst	Ph.D.	Determination of Terminal Amino Acid Residues Appearing During the Proteolysis of Lysozyme

UNIVERSITY OF ILLINOIS (URBANA)

Wm. J. Hoover	M.S.	Process Factors Affecting the Quality of Apple Jelly
Gopala K. Murthy	M.S.	The Effect of Ion Exchange Resins on the Salt Content of Skimmilk
Marvin P. Steinberg	Ph.D.	Studies on the Lipid Production Phase of Food Yeasts

UNIVERSITY OF MARYLAND (COLLEGE PARK)

Nazmy El-chwany	M.S.	Effect of Field Treatments on the Quality of Processed Tomatoes and Tomato Products

UNIVERSITY OF MASSACHUSETTS (AMHERST)

Harold Gorhen	Ph.D.	Effect of Environmental Factors on Composition of Cranberries
Eugene J. Finnegan	Ph.D.	Antioxidants of Cacao Shells
Gaston Kohn-Krenski	Ph.D.	Sediment in Clarified Apple Juice
Leonard R. Parkinson	Ph.D.	Mode of Action of Rodenticides
James H. Dietz	Ph.D.	Pectic Enzymes in Citrus Juice
Irving J. Pflug	Ph.D.	Thermal Resistance of Bacterial Spores in Temperature Range of 250-300° F.
Robert J. Vilece	Ph.D.	Non-Enzymatic Browning of Fruit and Vegetable Purees
Aaron Blank	M.S.	Thickening Agents for Relish
Mario Sereno	M.S.	Dietetic Cranberry Products
Manohar G. Sathe	M.S.	Stabilization of Frozen Eggs
Abdul T. El-Mohandes	M.S.	B-vitamins in Fenugreek
Herbert D. Brody	M.S.	Heat Stability of Vegetable Pigments
Narayan A. Pandit	M.S.	Non-Enzymatic Browning of Fruit Preserves
Avrom R. Handleman	M.S.	Bactericidal and Inhibition Properties of Essential Oils

RUTGERS UNIVERSITY (NEW BRUNSWICK, NEW JERSEY)

Warren Clauss	M.S.	Definition of Texture of Cooked Meat in Terms of Objectivity and Subjectivity Measurable Characteristics with Particular Reference to the Latter
Abner Salant	Ph.D.	Heat Penetration in Meat Processing
Benjamin Borenstein	Ph.D.	Pectic Changes and d-galacturonic Acid Changes in Tomatoes During Storage
Hormoz Broumand	Ph.D.	Methods for Determining the Chemical Changes in Fresh, Pre-packaged and Stored Meat. Development of Spectrophotometric Method for Identification of the Pigmented Compounds Present in the Meat

Annual Meeting Bulletin Board

IT'S LOS ANGELES IN '54 — JUNE 27 TO JULY 1

Program Preliminaries

The following briefs constitute the overture to the Fourteenth Annual Meeting of the Institute of Food Technologists to be held June 27 to July 1, 1954, at Los Angeles, California. The scene of activities will be the commodious Hotel Biltmore.

The firm policy of the 1954 IFT Program Committee is: *All good worthwhile papers will be accepted.* Sufficient space on the programs of the general sessions will be available to accommodate papers that may not fall, because of treatment or subject matter, into the symposia programs. It should not be necessary to caution prospective authors that adherence to deadlines is essential.

Abstracts of papers. Final abstracts of proposed papers must be in the hands of section leaders by February 1, 1954. Names and addresses of the various leaders will be listed in the September issue.

Certain tentative decisions concerning the program have been made. The committee is in general agree-

(Continued on page 8)

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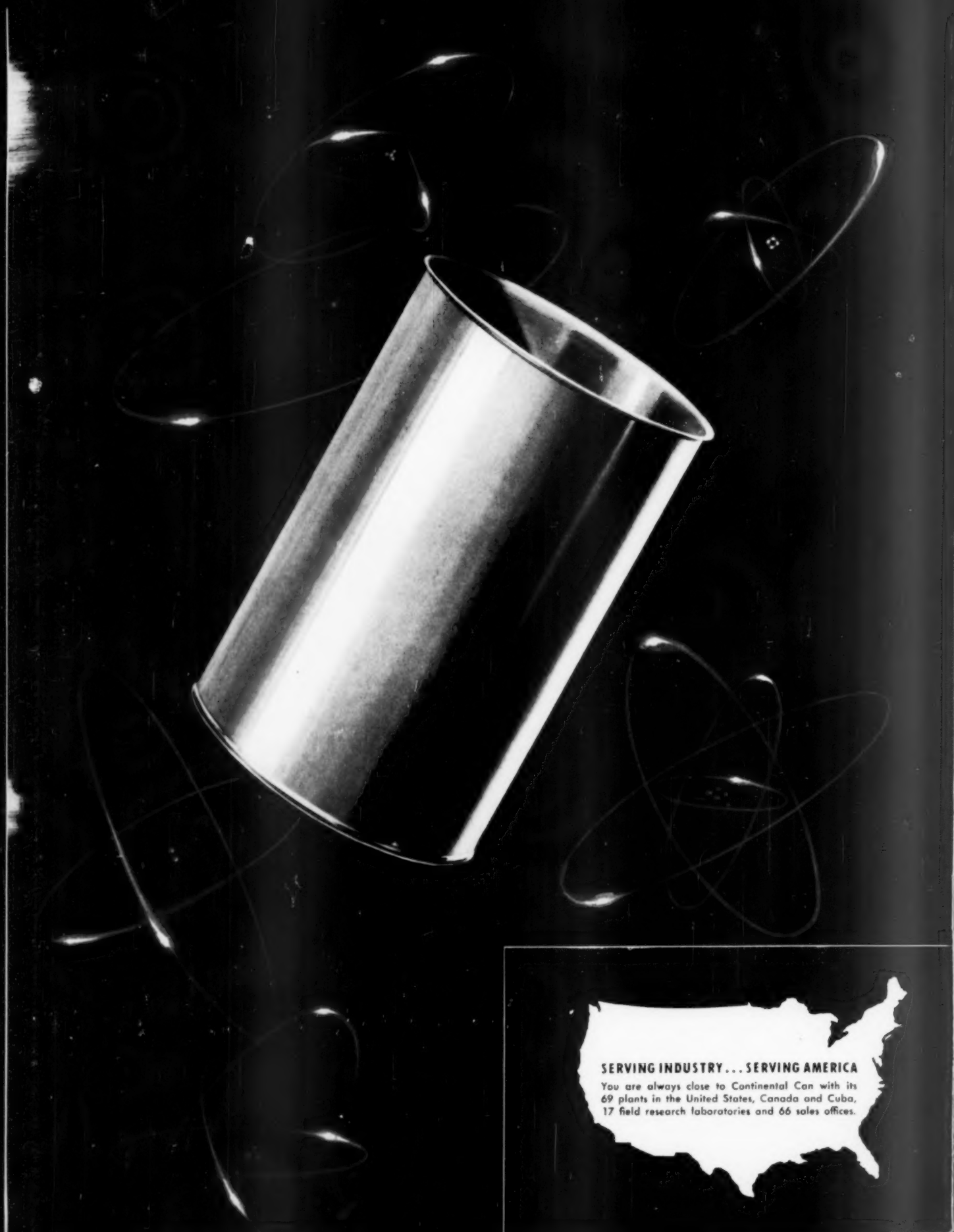
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Right now we are giving our support and financial backing to two universities whose laboratories are equipped to explore sterilization of foods by atomic radiation. Work is being conducted using mechanically generated multimillion volt cathode rays. Atomic fission waste products sources for gamma rays are also being investigated.

It has already been established that cold sterilization with atomic radiations will destroy all bacteria in foods without otherwise affecting them. Atomic sterilized foods are essentially like raw, fresh foods. But, from a commercial point of view, there are problems. Cost is one. Another is the safety of workers handling atomic fission products or high-voltage generating equipment. And there are many details which must be worked out concerning the food itself. So there is need for a great deal of further comprehensive investigation.

However, Continental scientists are convinced that the day will come when atomic radiations will be used to cold-sterilize certain packaged foods. We are encouraging and closely following research in this field. So if and when "atomic canning" becomes practical, Continental will be able to supply the best in containers and the best in counsel to the food-packing industry.

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Annual Meeting Bulletin Board

(Continued from page 4)

ment that the following symposia should be scheduled. The titles are only tentative and the list itself is incomplete at this point:

Problems in Fruit and Vegetable Research and Technology. Dr. Reese Vaughn is cooperating with Professor John H. MacGillivray, Professor of Vegetable Crops, University of California, at Davis, and is lining up a program of approximately four speakers to discuss (a) raw product problems and their solution before receiving, (b) raw product problems and their solution in the processing plant, (c) current vegetable research on processing problems, and (d) current fruit research on processing problems.

Flavor Changes in Foods as Influenced by Applied Chemicals. Dr. Charles H. Mahoney, of the National Canners Association, has accepted the responsibility of leading this symposium.

Food and Drug Standards. Mr. Charles W. Kaufman, Vice President, Kraft Foods Company, has accepted the responsibility of heading up this symposium.

Citrus Concentrates. Dr. W. R. Roy, of the Minute Maid Corporation, has agreed to take charge of this symposium.

Recent Basic Investigations in Food Science. Dr. Aksel G. Olsen, of General Foods, has accepted the responsibility for this one.

Marketing Problems. Dr. Roy H. Walters, of General Foods, has agreed to head up this symposium, but the particular emphasis desired has not yet been determined.

Special Purpose Foods. Dr. Ernest Geiger will organize the symposium on this subject.

Seafood and Seafood Problems. Mr. Karl Envoldsen, Envoldsen Shrimp, Inc. will lead this symposium.

Wine Symposium. Dr. Reese Vaughn is arranging, through Mr. Harold Berg, to have a good symposium on wine. In connection with this symposium it may be possible to set up an excellent tasting program.

Consumer Acceptance. The leader of this symposium will be announced later.

Poultry. This symposium is still in the exploratory stages at this writing. It is emphasized that this is a preliminary announcement. Complete and "finalized" details will appear in the September issue.

Regional Section News

DIXIE SECTION

The Dixie Section held its Regular and Annual Election Meeting, Friday May 15, 1953, at Atlantic Brewery, Atlanta, Georgia. The late afternoon was spent in making a guided tour of the complete plant and in a social hour in the Steinerbru Room of the brewery, followed by a buffet supper.

The evening program consisted of a lecture by Mr. Frank Santner, Supervising Brewmaster of the three Atlantic Company Breweries, who spoke on production techniques in the manufacture of beer and ale and showed a film entitled "Barley, Miracle Grain of the Modern World."

Section officers elected to serve in 1953-54 were:

Chairman: S. R. Cecil, Georgia Experiment Station, Experiment, Georgia.

Vice-Chairman: C. D. Schiffman, Federal Food and Drug Administration, Atlanta, Georgia.

Secretary-Treasurer: C. F. Neff, 193 Princeton Way, N. E., Atlanta, Georgia.

Editor: J. G. Woodroof, Georgia Experiment Station, Experiment, Georgia.

Councilor: J. J. Powers, University of Georgia, Athens, Georgia.

MARYLAND SECTION

The June meeting of the Maryland Section of the IFT was held at the Commissary of the Hot Shoppes in Washington, D. C. The manufacturing and preparation facilities of the company were viewed by the members in attendance. Dinner was held at one of the Hot Shoppe Units after which those present were addressed by three members of the staff on Food Preparation, Food Procurement and Records in Cost Accounting.

NEW YORK SECTION

Persons over 65 require about a third less dietary protein than younger adults; other than this, many dietary restrictions popularly believed necessary in feeding the aged have no basis in fact. Current research refutes the recommendation that elderly persons should avoid fats in an effort to slow hardening of the arteries. Nor do scientific data justify the belief that their sugar intake should be curtailed. These are the conclusions of Dr. Anthony A. Albanese, chief of nutritional research, St. Luke's Convalescent Hospital, Greenwich, Connecticut who spoke May 20 before the New York Section of the Institute of Food Technologists.

Dr. Albanese, a pioneer in the study of the nutrition of the aged, has conducted nutrition studies both at the Convalescent Hospital, which is a branch of St. Luke's Hospital in New York City, and at various homes for the aged. He based his conclusions on these studies and on related work of many other investigators which have placed the science of geriatric nutrition on a sounder scientific basis.

Speaking of the fat content of the diet and its possible implications in hardening of the arteries, Dr. Albanese stated that these changes now are known to start with an alteration of protein struction of the blood vessel and the deposition of fat is secondary. He went on to relate that there is little or no evidence that cholesterol blood levels are related to the occurrence of arterosclerosis. There is no logic in attempting to reduce the intake of cholesterol by reducing foods high in this substance, such as eggs, milk, and cheese, as the body can form cholesterol from amino acids and increases its formation when the diet is low in cholesterol.

Therefore, said Dr. Albanese, it is not rational to recommend a low-fat diet for the elderly. On the contrary, a diet even slightly high in fat may be more suited to the upper age range, as the body composition changes

(Continued on page 10)

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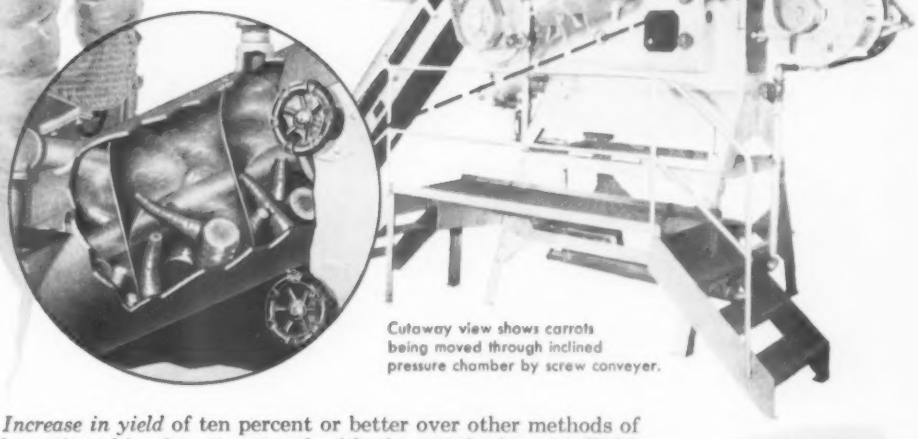

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Regional Section News

(Continued from page 8)

with age in the direction of a higher percentage of fat and a lower percentage of protein. In this connection he has found that self-selected diets of elderly women contained from 5 to 10% more fat than is considered normal for younger adults and infants.

Study of the diets which old persons selected for themselves also yielded the clue to the conclusion that those over 65 probably require from 20 to 30% less dietary protein than the National Research Council recommendation for adults. On such relatively low protein diets, the elderly women remained in good health and showed no decline in body nitrogen content or in hemoglobin and serum protein.

This evidence, the speaker stated, provides no grounds for the belief that a high-protein diet is required in old age, except, of course during short periods of convalescence when it is necessary to restore rapidly the protein stores depleted by disease. Extra high protein for extended lengths of time may be harmful, he added.

Recommendations which have been current regarding the intake of carbohydrates are the most fanciful of all, Dr. Albanese continued. "These run mostly to the categorical instruction to avoid all sugars, and cane sugar in particular." However, the consumption of fruits is always encouraged, in blissful disregard of their high sugar content. Such recommendations, he said, fail to acknowledge the basic need in the balanced diet for carbohydrates, a certain portion of which are converted to protein. "Since proteins are the costly portion of any diet, it is good economy to secure the maximum protein-sparing action that we can from the inexpensive carbohydrates."

There is positive experimental evidence that the components of cane sugar are more readily utilized by oldsters than other sugars, Dr. Albanese continued. Hence, he asserted, it would seem wise now to recommend a normal intake of cane sugar in a properly balanced diet for the elderly.

The following officers were elected at the meeting:

Chairman: A. A. Schaal, Good Housekeeping Bureau.
Vice Chairman: A. J. Finberg, Chemicolloid Laboratories Inc.
Secretary: Eleanor Crozier, United Fruit Company.
Treasurer: A. H. Gee, Foster D. Snell, Inc.
National Councellors: O. Skovholt, Quality Bakers of America; R. Light, Fleischmann Laboratories; C. Frey, Consultant.
Local Board of Directors: L. Atkin, Standard Brands Inc.; J. Bauernfeind, Hoffmann-La Roche Company; H. Campbell, General Foods Corporation; P. Hoynak, Refined Syrups and Sugars Inc.; P. Kratz, Hoffman Beverage Company; D. Melnick, The Best Foods Inc.; F. Seymour-Jones, The Borden Company; R. Sherwood, Sterwin Chemicals Company; J. Sluder, The Nestle Company.

PHILADELPHIA SECTION

The Philadelphia Section met on Tuesday, May 19, 1953, at the Drexel Institute of Technology. After dinner at the Faculty Club, a sound movie in color, "The Inside Story of Cake Baking," was shown. After the movie Mr. George T. Carlin, Assistant Director of Research, Swift & Company, spoke on "Technological Advances in the Processing of Fats and Oils, and the Use of Fats and Oils in the Food Industry." The movie produced by Mr. Carlin was in color and showed the changes taking place during the baking of a cake. The baking takes place under a microscope and the photomicrographic pictures are projected onto the screen.

BUFFALO SECTION

The Buffalo Chapter of the Western New York Section of the IFT met in Buffalo recently and chose the following members as program committee for the 1953-54 season: Chairman, Fred Ziman; Associates, Paul W. Hodler, Jerry Hoger, and Francis Tolan. The committee is planning a series of informative meetings on recent developments in the food technology field including packaging and freezing of varied foodstuffs.

AUSTRALIA NORTHERN SECTION

The Australia Northern Section held a very successful meeting on Tuesday, April 21st at the Commonwealth Scientific and Industrial Research Organization's Division of Food Preservation laboratories, Homebush, N. S. W.

Dr. J. R. Vickery, Chief of the Division, received the visitors at 2:30 p.m. and invited them to inspect the laboratories and discuss current research programmes. The visitors were conducted in parties through those sections of most interest to the group: Organic Chemistry, Biochemistry, Physics, Egg Investigations, Microbiology, Canning, Dehydration, and Freezing.

Around 5 p.m. the group gathered for a social hour with suitable refreshments, and at 6 p.m. they were called to the canteen to attack a buffet dinner of epicurean dimensions in keeping with the reputation of a food research establishment. It is regrettable but not surprising that some members appeared to have difficulty in keeping awake during the meeting which followed.

The majority, however, listened with great interest to a discussion of the applications of paper chromatography and ion exchange in food research. The speakers, Dr. A. Ash and Dr. E. F. Anet, are actively working in this field in the Division of Food Preservation, and they illustrated modern techniques for the separations of amino acids, sugars, and organic acids by showing results of their own work on the soluble constituents of apricots and peaches. And during the course of the meeting, they ran a very pretty demonstration of the separation on paper of a mixture of synthetic food colours.

PERSONNEL

Dr. Robert G. Tischer, formerly of Iowa State College and the Food Processing Laboratory of that institution, is now fully established in his new post as Director of Food Laboratories, QM Food and Container Institute, Chicago, where he is directing a comprehensive program of investigation relating to ration improvement. Dr. Tischer and his associates will maintain the

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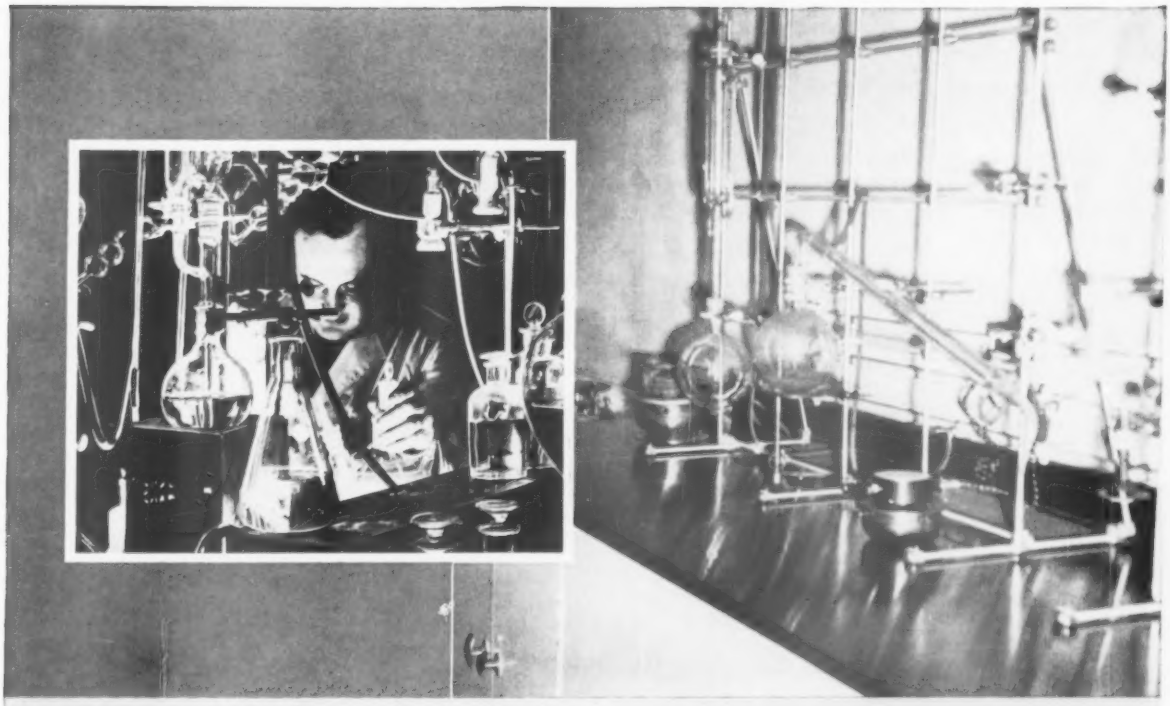

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Regional Section News

(Continued from page 10)

close professional associations with industry, government, and university research workers that have been so profitable to the Armed Forces feeding program over the past several years.

Books

MAN'S FOODS. Nutrition and Environments in Food Gathering Times and Food Producing Time. Lloyd B. Jensen, 278 pages, The Garrard Press, Champaign, Ill., 1953. $4.50.

This book is the outcome of a new and thought-provoking approach to the fascinating story of man's foods. By drawing upon a broad background in the natural sciences and beginning with earliest man, the author has been able to integrate complex relationships concerned with the rise of food production and civilization.

The basic theme is that civilization cannot expand, or even survive, if man must devote the greater part of his time to gathering his food from the field and forest and from the animals that roam the land. For nearly a million years man existed as a food gatherer, and it was not until about 7,000 B.C., when the ice age ended and population began to increase that man tilled the land and domesticated animals for food production. This transition of man from a food-gatherer to a food-producer, marked the beginnings of civilization.

The author devotes the first part of the book to tracing the many interesting skills developed by the food gatherers in obtaining their food and shelter. Like our own Indians, prehistoric man was masterful in obtaining his meat through the use of fire and noise to drive herds of animals into pitfalls, over cliffs, or into caves to be suffocated by smoke. No abhorrence was held by these primitive peoples for cannabilism or the extensive use of grubs, slugs, insects, etc., in the diet.

In the second part, Dr. Jensen reveals how the foundations of civilization were laid through shifting of man's food procurement efforts to cereal, vegetable and live stock farming. As the "Neolithic Revolution" forced man to seek "Lebensraum" he migrated into areas suited by nature to the growing of wheat and other cereals, and from that time on man began to produce, rather than gather, his principal food materials. With the development of improved methods for supplying his food, man found time to devote to other activities. Civilization expanded rapidly and even war, in a sense, resulted from man's activities as a food producer. A greater ease of living came to man, so he had more time for piracy and organized warfare than was possible when he had to devote full time to scrounging for his food.

The third part of this book briefly integrates some of the effects of environment and man's own cultural characteristics upon his choice and preparation of foods during his long history. A survey is made of man's nutrition and how it has affected, not only his health, but his physical stature as well. In his long development, the greatest of these bodily changes have taken place in the teeth and jaws. History shows that changes in food over the centuries have brought about a reduction and simplification of human dentition that have strikingly altered man's head shape.

This book, with over 600 references, provides an excellent bibliography of many unusual and new aspects of man and his foods that are not too well-known to those working in the field of nutrition. It is highly recommended to all [scientists and laymen] who are interested in food technology and nutrition.

WILLIAM R. JOHNSTON.

Selected Abstracts*

ANALYTICAL METHODS

Methods for determining peroxide in lipids.

LEA, C. H. *J. Sci. Food Agr., 3,* 586-94 (1952).

The relative efficiencies of three methods for the dctn. of peroxide oxygen in fatty materials were compared using methyl oleate, linoleate and linolenate oxidized under standard conditions to known oxygen-absorptions. The iodometric method indicated for the conversion of 71-91% of the oxygen absorbed to peroxy-compds., but the ferric thiocyanate and *2*:6-dichlorophenolindophenol methods both gave abnormally high results in the presence of atm. oxygen, and values which were obviously too low in its absence. Nevertheless, the aerobic ferric thiocyanate method shows excellent reproducibility, requires much less material than the iodometric method, and under any one set of conditions gives results which appear to be directly proportional to the iodometric values. The *2*:6-dichlorophenolindophenol method behaved similarly in most respects to the ferric thiocyanate method, but reproducibility appeared to be poorer and interference by atm. oxygen and by traces of copper when present was more marked.

A modified photometric ninhydrin method for the analysis of amino and imino acids.

TROLL, W., AND CANNAN, R. K. *J. Biol. Chem., 200,* 803-11 (1953).

A modified procedure is described for the photometric dctn. of amino acids with ninhydrin. Ten of the naturally occurring amino acids give theoretical yields of color at room temp. At 100° all amino acids, except tryptophan and lysine, react quantitatively. A method for the photometric estn. of hydroxyproline in amino acid mixts. is described. It is based on the extn. of a red deriv. from the reaction system with benzene. This pigment is a precursor of the yellow compd. which is the final product of the reaction with ninhydrin.

Gradient elution analysis.

WILLIAMS, R. J. P. *Analyst, 77,* 905-14 (1952).

Some limitations of current chromatographic procedures are discussed and the suggestion is made that gradient elution analysis overcomes a no. of them, although it has certain disadvantages. This suggestion is supported by exptl. evidence on the resolution of amino acids and peptides in cases where the standard procedures yield unsatisfactory results. Initial expts. are described using this procedure but in which the column has no adsorbent properties and is only used as a support.

Gravimetric estimation of proteins precipitated by trichloroacetic acid.

HOCH, F. L., AND VALLEE, B. L. *Anal. Chem., 25,* 317-20 (1953).

Trichloroacetic acid has been used widely as a specific and quant. pptg. agent for proteins and to sep. them from nonprotein

* These Selected Abstracts are made available to FOOD TECHNOLOGY through the cooperation of Associate Editor H. A. Campbell and the General Foods Corporation of New York, N. Y. The abbreviations found in these abstracts are similar to those used by Chemical Abstracts.

(Continued on page 14)

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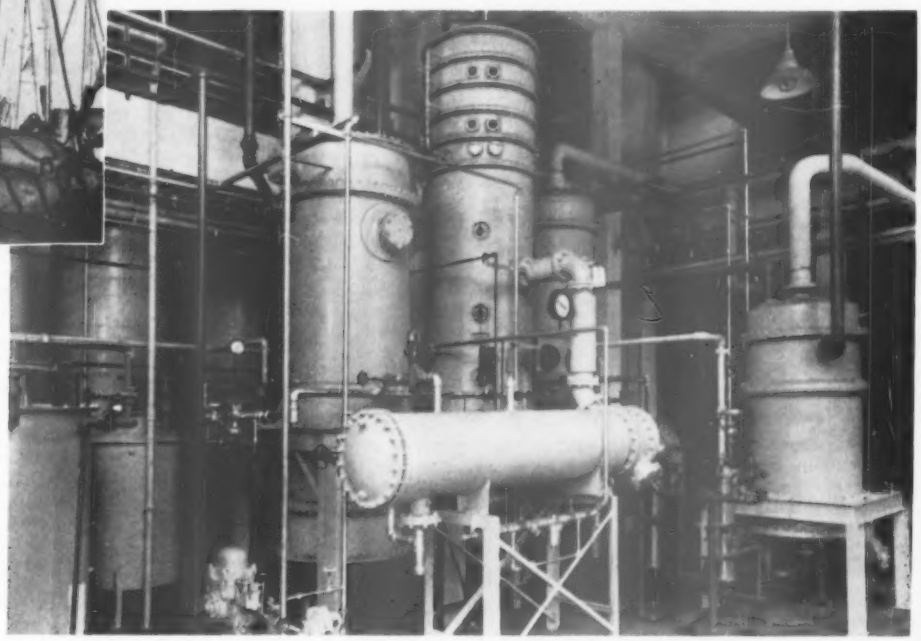

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Abstracts

(Continued from page 12)

substances, protein-bound cations, and org. groups. Weighing of these protein residues, properly dried, may allow estn. of anhydrous mass and direct correlation with properties of these proteins while in soln. Such wts. are in excellent agreement with wts. of cryst. proteins, with protein detns. by optical measurements at 280 mμ, and estimates of wt. on the basis of nitrogen detns. The method results in quant. recovery of proteins from soln. Proteins are not hydrolyzed. Mol. wt. does not appear to be the detg. factor in trichloroacetic pptn. of proteins of mol. wt. above 12,000.

BIOLOGICAL SCIENCES

BIOCHEMISTRY

Comparison of effect of vitamin B_{12} with that of liver extract in treatment of pernicious anemia.

MURPHY, W. P., AND HOWARD, I. *New England J. Med., 247*, 838 (1952); *J. Am. Med. Assoc., 151*, 770 (1953).

It was not possible to predict conclusively the relative potency of the U. S. P. antipernicious anemia unit of liver ext. and 1 μg of vitamin B_{12}, but the erythrocyte increase seemed to suggest that the effect of 1 U. S. P. unit of liver ext. is greater than that of 1 μg of vitamin B_{12}. The authors believe that 1 U. S. P. unit is perhaps equiv. to 1.3 of vitamin B_{12} as opposed to the 1:1 ratio previously suggested.

A sparing effect by formate or methanol on the impairment of creatine metabolism in folic acid deficiency.

FALLERPAKER, P., MARFATIA, V., AND SKEENWASAN, A. *Nature, 170*, 894-5 (1953).

The impairment in creatine metabolism in mice brought about by folic acid deficiency is partially restored by the administration of methanol; the effect due to formate is less pronounced.

Role of the vitamins in antibody production.

AXELROD, A. E. *Metabolism, 2*, 1-8 (1953).

The available evidence indicates that certain B vitamins, notably pyridoxine, pantothenic acid and pteroylglutamic acid, play a significant role in antibody synthesis. There is considerable basis for linking pyridoxine to amino acid metabolism, and its participation in antibody production may be related to this function.

Insulin and the permeability of cell membranes to glucose.

ROSS, E. J. *Nature, 171*, 125 (1953).

Support for the concept that insulin increases the permeability of cells to sugars is presented. Isolated rabbit eye lenses were incubated with glucose, arabinose or sucrose in the presence of insulin. Insulin increased the rate of uptake of glucose 350% over the controls. Galactose, normally not taken up by the lens, was absorbed at significantly high levels in the presence of insulin. Sucrose was not taken up in any case.

Normal liver proteins differ from cancerous.

Science News Letter, 63, 76 (1953).

The liver of a normal, adult rat contains proteins which show distinct and consistent differences from proteins from a liver of a cancerous rat.

MICROBIOLOGY

Effect of alcohols on the mycological production of citric acid in surface and submerged culture. I. Nature of the alcohol effect.

MOYER, A. J. *Appl. Microbiology, 1*, 1-7 (1953).

The addn. of methanol or ethanol greatly stimulates the production of citric acid by *Aspergillus niger*. Methanol on a vol. basis is more effective than ethanol, which itself can be assimilated and converted to citric acid. The effectiveness of these alcs. is increased by medium acidification. Higher levels of zinc, iron, and manganese can be tolerated in either surface or submerged culture for citric acid fermentation if a slightly toxic concn. of alc. is present. The use of methanol to stimulate citric acid production should find application in the com. production of this acid.

The rate of growth of salmonellas and other bacteria in some synthetic creams.

BAILLIE, A. J., AND FREEMAN, G. G. *J. Sci. Food Agr., 3*, 616-22 (1952).

The development of representative salmonellas (*Salmonella enteritidis* [Gaertner] and *Salmonella paratyphi B*) and of spore-forming organisms which resist pasteurization was studied in synthetic creams. The creams consisted of (a) a vegetable oil emulsified in an aq. soln. of cellulose ethers ('cellulose ether cream') and (b) the oil emulsified in a medium contg. egg yolk and sodium alginate ('egg cream'). Rapid growth of the salmonellas to populations of 30-40 x 10^6 cells/g. took place in the egg cream within three days at 18-20°, but practically no growth occurred in the cellulose ether cream. No change in the appearance or odor of the creams was evident. The presence of a heat-resistant, mixed microflora did not significantly influence the growth of the salmonellas in egg or cellulose ether creams. Growth of the organisms which resisted pasteurization was more rapid in the egg cream than in the cellulose ether cream at 18-20°, and was accompanied by development of putrid odors in the egg cream. No detectable growth took place in either cream after incubation at 1-8° for 22 days. It is recommended that where refrigerated storage is not available, storage periods not exceeding 4-6 days and 3-4 days at 18-20° be adopted for cellulose ether and egg creams resp.

A plating medium for the isolation and enumeration of enterococci.

REINBOLD, G. W., SWERN, M., AND HUSSONG, R. V. *J. Dairy Sci., 36*, 1-6 (1953).

A selective plating medium for the isolation and identification of the enterococcus group of streptococci was developed. The method is based upon the ability of the enterococci to utilize sodium citrate as an available carbon source, to convert ditetrazolium chloride to a blue diformazan and to grow in the presence of 0.01% sodium azide. Results are presented which show that the selective plating medium can be used to isolate and est. the nos. of enterococci in raw milk.

Bacterial polysaccharides.

STACEY, M. *Endeavour, 12*, 38-42, January, 1953.

Bacterial polysaccharides form part of the cell-building material, and also occur on the cell surface. They are important in medicine as immunizing and diagnostic agents, and derivs. of one of them are finding increasing use as a blood-plasma substitute and a blood anticoagulant. In soils, bacterial polysaccharides are important as moisture conservers. Their structures are highly complex, and investigations in this field have revealed an important relationship between chem. constitution and serological specificity.

Chemicals "return" bacteria to "life."

Science News Letter, 63, 28 (1953).

Bacteria "killed" by ultraviolet irradiation have been "returned to life" by exposing them for 24 hrs. to sodium pyruvate and similar chemicals. These bacterial suspensions had been considered sterile by all usual standards. The discovery points up unrecognized dangers in the re-contamination of sterilized objects by contact with chemicals. A possible benefit from this discovery may be to increase our knowledge about irradiation effects on higher animals, including man.

Bacteria at bay.

Monsanto Mag., 7-9, February-March, 1953.

Monsanto has come up with a chem., 2,2'-thiobis (4,6-dichlorophenol), which checks skin microbes, *micrococcus pyogenes var. aureus*, probable source of body odor. Monsanto has trade marked it *Actamer*. This chem. is not new; however, its value as a bacteriostat has only recently come to light. *Actamer* is now being used in soap; however its possibilities are numerous.

NUTRITION

A radiological study of the rate of passage of brown and white bread through the digestive tract of man.

MCCANCE, R. A., PRIOR, K. M., AND WIDDOWSON, E. M. *Brit. J. Nutrition, 7*, 98-103 (1953).

(Continued on page 16)

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Abstracts

(Continued from page 14)

The passage of brown and white bread through the alimentary tracts of six healthy men and women was studied radiologically by the addn. of a small quantity of barium sulfate to the bread. The brown bread appeared to stimulate a greater secretion of saliva or of gastric juice or of both than did the white bread. The brown bread was evacuated from the stomach and passed through the small intestine more rapidly than the white bread. The residue from the brown bread, when in the ileum and in the colon, appeared to be greater than that from the white bread. The residue from the brown bread left the colon 24 hrs. sooner than that from the white bread.

The effect of fruit-syrup supplements on the assimilation of food from the alimentary canal. II. Their effect on the growth rate, nitrogen assimilation and calorie intake of young rats.

FAWNS, H. T., AND BOURNE, G. H. *Brit. J. Nutrition, 7,* 21-8 (1953).

Three fruit syrups, loganberry, raspberry and strawberry, mixed with milk in the ratio 1:4, were fed to three groups of rats, and their growth rates, nitrogen absorption and cal. intakes compared with those of three control groups receiving resp., milk and sucrose, milk and water, and water only. All groups ate *ad lib.* an adequate basal ration. Rats receiving 10 ml. of syrup supplement daily for 20 days, showed no deterioration in general health, growth rate or cal. intake. Doubling the supplement to 20 ml. daily for a short 5-day period at the end of the expt. produced a slight diminution in the wt. gains of the syrup-fed animals which, if significant, was probably due to curtailment of appetite. This was reflected by a decrease in the cal. intake. No changes specifically referable to the syrups could be observed in the values for nitrogen absorption.

Effect of previous lactose feeding upon intestinal absorption of lactose in the rat.

FISCHER, J. E., AND SUTTON, T. S. *J. Dairy Sci., 36,* 7-10 (1953).

The rate of intestinal "absorption" of lactose in the rat was greater after previous feeding for six weeks of a diet contg. 25% of lactose than after similar feeding of a comparable diet contg. no lactose. The mean "absorption" coeffs. (± the standard error of the mean) were 88 ± 12 and 57 ± 6 mg./100 g./hr., for the 25% lactose-fed and the non-lactose fed groups, resp.

Effect of type of protein on the response of young dairy calves to aureomycin with data on the intestinal microflora.

RUSOFF, L. L., ALFORD, J. A., AND HYDE, C. E. *J. Dairy Sci., 36,* 45-51 (1953).

An aureomycin-supplemented vegetable calf starter contg. solvent-extd. soybean oil meal as the main source of protein showed a better growth response and more improved feed efficiency than when it contained either hydraulic or degossypolized cottonseed meal. Aureomycin-fed calves showed a growth increase of 10 to 20% over control calves at 16 weeks of age. A bacteriol. study of the fecal contents indicated that the mode of action of aureomycin in stimulating calf growth apparently is not due to selective bacterial inhibition of the common bacterial groups of the intestines, namely, coliforms, enterococci, and *Clostridium perfringens* types. Other microorganisms or other mechanisms may be involved.

The liver in obesity.

ZELMAN, S. *Arch. Internal Med., 90* (2), 141-56 (1952); *Biol. Abstr., 27,* 323, No. 3399 (1953).

Twenty obese men who were between 50 and 100% overwt. were studied for liver disturbance by multiple lab. tests and needle biopsy. All subjects showed both lab. and histologic evidence of liver disease. An explanation of the liver damage of obesity is found in (a) the high caloric requirements of the obese, constituting a functional overload upon the liver, (b) the high carbohydrate, high fat, low protein diet customary among the obese, and (c) the increased requirement of choline and B vitamins imposed by the quant. and qual. nature of the obese diet. The reducing program should consist of a high protein diet supplemented by choline and B vitamins.

A social and food survey of the elderly, living alone or as married couples.

BRANSBY, E. R., AND OSBORNE, B. *Brit. J. Nutrition, 7,* 160-79 (1953).

A social and food survey of elderly men and women was made in Sheffield between January 1950 and March 1951 as part of a more comprehensive health survey. The survey was restricted to men and women living alone or as married couples without any other person. Information of three kinds was collected from each individual for a period of 1 week on (1) social and domestic circumstances, (2) economic circumstances, (3) food consumption.

Effect of fluoridated public water supplies on dental caries prevalence.

ARNOLD, F. A., DEAN, H. T., AND KNUTSON, J. W. *Public Health Repts., 68,* 141-7 (1953).

The methodology and results after 7 years of the Grand Rapids-Muskegon study are described. The 1951 results on continuous resident children after 6½ yrs. of fluoridation of the Grand Rapids water supply indicate: 1. There has been a reduction in dental caries rates in permanent teeth from 66.6% in 6 yr.-old children to 18.1% in the 16-yr. old age group. Similar results have been obtained regarding the deciduous teeth. 2. Similar reductions have not been observed in Muskegon where the water supply remained "fluoride-free" (<0.2 p.p.m. F) until the last 3 months of this study period. The use of a fluoridated water gives the same beneficial effects as does the use of a natural fluoride water of similar concn.

ENGINEERING AND PLANT EQUIPMENT

Mixing of liquids in chemical processing.

RUSHTON, J. H. *Ind. Eng. Chem., 44,* 2931-6 (1952).

Article reviews present status of theory on mixing liquids in chem. processing by bringing together the more significant developments of the past ten years and showing how they complement each other. A large amt. of information has become available during this ten-year period.

FOOD AND FOOD TECHNOLOGY

Production and consumer aspects of low-sodium canned foods.

CLIFCORN, L. E. *J. Am. Dietet. Assoc., 29,* 116-20 (1953).

The National Canners Association-Can Manufacturers Institute Nutrition Program has conducted an extensive investigation on the sodium compn. of a number of low-sodium canned foods. The data are presently being made available to the medical profession, dietitians, and patients for low-sodium diet therapy. Certain canning practices in which sodium contamination may occur were investigated and found in several instances to be undesirable in the prepn. of low-sodium canned foods. Canners have been properly advised in this regard. The advice of the Food and Drug Administration on labeling dietetic canned foods, including low-sodium canned foods, has been clearly presented. It is the desire of those stimulating these efforts that they will be useful to canners in better production control and labeling of these products, and result in the more intelligent and helpful use of these products by those prescribing or using low-sodium diet therapy.

Flavor of bread.

BAKER, J. C., PARKER, H. K., AND FORTMANN, K. L. *Cereal Chem., 30,* 22-30 (1953).

The origin of bread flavor was classified into three broad groups, namely, ingredients, fermentation, and baking. It was demonstrated that fermentation and the formation of a brown crust are essential for satisfactory flavor. Ethyl alc., acetaldehyde, fusel oil, pyruvic aldehyde, diacetyl, furfural, acetic acid, along with iso-aldehydes, ketones and esters were identified in condensates of the vapors from bread baked after normal and excessive fermentations. The quantities of the individual constituents in the condensate varied from a trace to 12%. Bread flavor can be improved in practice by avoiding too fine a crumb and excessively large vol., by altering baking to affect produc-

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Abstracts

(Continued from page 16)

tion of aldehydes and thus control the extent of browning, by increasing flavor components arising from amino acids and by retention of volatile flavor components in the crumb through faster baking and quicker wrapping.

A cake baking method for evaluating wheat varieties.

SUNDBERG, D. F., HAYASHI, R., AND BARMORE, M. A. *Cereal Chem., 30,* 1-11 (1953).

Studies with single and two-stage methods of mixing cake batters employing commercially and experimentally milled flours showed that the two-stage method revealed greater differences between flours.

Interaction of chlorine dioxide with flour: certain chemical aspects.

MORAN, T., PACE, J., AND MCDERMOTT, E. E. *Nature, 171,* 103-6 (1953).

The lipoids of flour interact readily with chlorine dioxide and with chlorine. With pure chlorine dioxide, the unsatd. fatty acids are the initial sites of an oxidative process which appears to include some degree of polymerization. The tocopherol content of ClO_2-treated flour was reduced by about 70% compared with untreated flour. The amino acid residues which are attacked by ClO, and which give ninhydrin positive modifications which are stable to total acid hydrolysis are methionine, cysteine and tyrosine. On none of the treated fractions was the agene toxic factor—methionine sulfoxamine—present. No acute toxic properties of chlorine dioxide-treated flour were observed in limited feeding trials.

An after-effect in butter-fat irradiated with high-energy electrons.

HANNAN, R. S., AND SHEPHERD, H. J. *Nature, 170,* 1021-2 (1952).

Oxidative changes which occur during irradiation of butter-fat with high-energy β rays are often continued after radiation is stopped. This after-effect is greatest at —20° C.

Preparation of peroxide concentrates from autoxidized fatty acid esters.

PRIVETT, O. S., LUNDBERRY, W. O., AND NICKELL, C. *J. Am. Oil Chemists' Soc., 30,* 17-21 (1953).

Details of a countercurrent extn. procedure for the quant. sepn. of the oxidized and unoxidized fractions of autoxidized fatty acid esters are described.

Fat substitutes in ice cream.

DYKSTRA, R. R. *Vet. Med., 48,* 163 (1953).

"Creamless" ice-cream is now offered for sale in Illinois, Oklahoma, Texas, and Missouri. Instead of cream, its principal ingredient is a vegetable oil such as cottonseed, soybean, peanut or coconut oil to replace the butterfat. It lacks certain vitamins, but can be fortified against this deficiency. It comes in a variety of flavors so that, to many people, it cannot be distinguished by taste from dairy ice-cream. It is much cheaper than butterfat ice-cream. Federal regulations do not permit interstate shipment of the artificial ice-cream.

Coliform count standard urged for ice cream.

Public Health Repts., 68, 244 (1953).

Because coliform organisms in frozen desserts reveal poor sanitary practice, the assistant director of the bureau of labs., N. Y. City Dept. of Health, recommended revision of the APHA manual "Standard Methods for Examination of Dairy Products" to include a coliform standard for ice cream. At present, it only gives directions for coliform tests. A subcommittee suggested a coliform standard count be set for ice cream "in the region of 10/ml. with a provision that three of every four samples comply." Of the samples studied, 70% revealed a count of 10 coliform organisms or less per ml.

The enzymic degradation of pectin and other polysaccharides. II. Application of the "cup-plate" assay to the estimation of enzymes.

DINGLE, J., REID, W. W., AND SOLOMONS, G. L. *J. Sci. Food Agr., 4,* 149-55 (1953).

The agar 'cup-plate' diffusion technic was applied to the quant. detn. of enzyme activity, principally to amylase, polygalacturonase, cellulase, protease and pectin-esterase. With all enzymes so far examd., the relationship between diameter of zone and log (amt. of enzyme) is linear over a wide range, and may be used for the quant. estn. of the enzymes. The cup-plate assay of polygalacturonase, like viscometric methods, measures the initial destruction of the colloidal properties of pectic acid, and, owing to the complex nature of polygalacturonase, bears no simple relationship to the assay of polygalacturonase by the estn. of glycosidic hydrolysis.

The selective staining of intact and damaged starch granules by Safranin O and Niagara blue 4B.

BAKER, F., AND HOBSON, P. N. *J. Sci. Food Agr., 3,* 608-12 (1952).

A rapid differential-staining method for distinguishing damaged from whole starch granules is described. The method has been applied to plant starches of different origins and to starches damaged by mech. and chem. means. A relationship is shown to exist between the no. of damaged granules, as shown by selective staining, and the susceptibility of the starch to enzymic hydrolysis.

Low-grade sugar, a potential carbohydrate feedstuff for laying chickens.

ROSENBERG, M. M. *Poultry Sci., 32,* 69-77 (1953).

Various levels of low grade sugar were added to a control feed ration. At a level of 32.25%, greater egg production and increased economy of feed conversion resulted. Egg wts., body wt. and hatchability were not adversely affected at this concn.

The utilization of ammoniated industrial by-products and urea by sheep.

TILLMAN, A. D., AND SWIFT, R. W. *J. Animal Sci., 12,* 201-11 (1953).

Ammoniated condensed distillers molasses solubles, ammoniated cane molasses and urea were mixed with cerelose and a basal mixt. composed of natural feedstuffs in such a way that the total rations were iso-caloric and iso-nitrogenous and compared to soybean oil meal. The following results were obtained: 1. The ration constituents of the urea-contg. ration were digested as well as the soybean oil meal ration. 2. Both ammoniated products were palatable to sheep when fed at a level of 10% by wt. of the total ration.

Influence of oxalic acid on absorption and separation of calcium by humans and animals. Examination of chemical qualities of some varieties of spinach.

DOESBURG, J. J. *Voeding, 13,* 227-40 (1952); *Brit. Abst., A III,* 1732 (1952).

A survey of the literature on the food value of Ca in greens contg. a high oxalic acid content shows it to be worthless. Excess of sol. oxalic acid may result in the withdrawal of Ca from other foodstuffs in the diet. The amt. of such Ca is usually considerably less than the equiv. Ca which could be pptd. by the sol. oxalates. The nutritive value of Ca in plants is influenced by the oxalic acid/Ca ratio. A low ratio and a high Ca value are desirable; these are found among the cruciferae (kale, cress, horse radish, turnip greens). Centrospermae and polygonales (spinach, Swiss chard, buckwheat, rhubarb) show a high ratio and high Ca content.

Studies in cold storage of potatoes.

MATHUR, P. B. *J. Sci. and Indus. Res., 10B,* 224-8 (1951); *Refrig. Abstrs., 8,* 16 (1953).

The loss in wt. suffered by stored potatoes is least when the storage temp. is 41° F. The increase in sucrose during storage was highest at 32° F. and this increase is correlated with the high respiration rate observed at that temp. Wt. losses were lower in small-sized potatoes than in larger ones. The losses were low when the potatoes were free from surface injuries. When injuries are present, it would be advantageous to subject them to a temp. of 104° F. for 16 hr. to stimulate the formation of a protective skin, and then to transfer them to cold storage. Seed potatoes stored at 50° F. gave the highest crop yield. 8 references.

(Continued on page 22 following technical papers)

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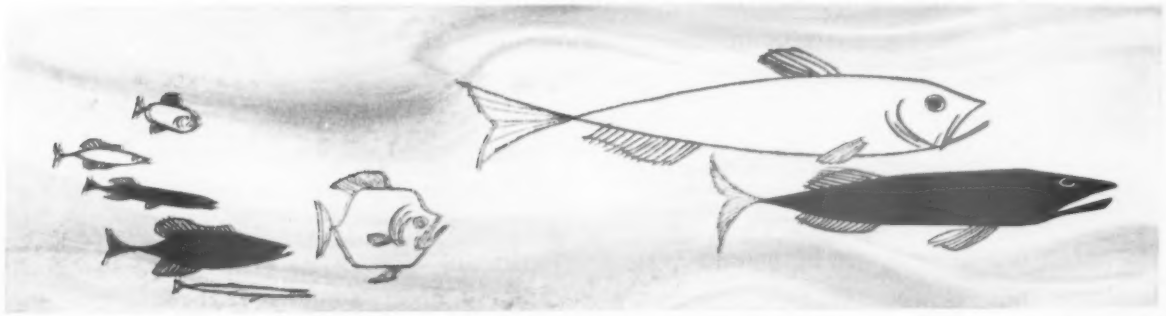

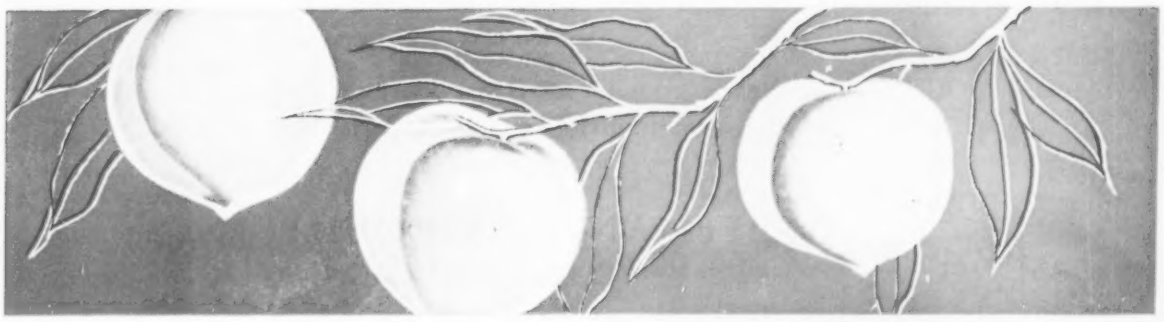

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Stable Foams from Food Proteins with Polyphosphates[a]

MARY ANN LEWIS, VIRGINIA MARCELLI AND BETTY M. WATTS[b]
Department of Foods and Nutrition, Syracuse University, Syracuse, N. Y.

(Manuscript received June 9, 1951)

The effect of adding sequestering agents to nonfat milk solids to improve whipping quality is described. Hexametaphosphate and tripolyphosphate were demonstrated to be superior to the other agents measured. These polyphosphates also improve the whipping quality of dried whole eggs and soybean flour.

During experiments in this laboratory on the antioxidant activity of the polyphosphates *(20)* it was noted that their addition to dried skim milk increased the tendency to produce foams. The present study was undertaken to investigate this property more thoroughly with the general objective of improving the whipping ability of nonfat milk solids and other dried protein foods.

The use of the polyphosphates as foaming agents for protein foods is not new. A treatment of gelatin for improvement of its whipping qualities for use in marshmallows involves adding sodium hexametaphosphate or other hydrates of P_2O_5 *(8)*. The polyphosphates, in this case, are as effective when added to the gelatin before it is dried as when they are added just before using. However, there is a limit to the length of time the solution can be held since the polyphosphates hydrolyze to orthophosphates *(9)*. A dried skim milk product capable of forming a stable foam of good volume has been prepared by Lindewald and Gruben *(13)* by adding rennet and a substance capable of forming undissociated compounds with calcium ions (sodium pyrophosphate, orthophosphate, hexametaphosphate, tartrate, or carbonate) and drying.

The specific objectives of the present study were (a) to compare the polyphosphates with several other sequestering agents in their effectiveness in improving whipping when added to commercial samples of nonfat milk solids, (b) to extend the observations on the effect of the polyphosphates to dried whole egg and fat-free soybean flour which resemble dried skim milk in that they can be made to produce stable foams, (c) to establish optimum conditions of concentration, pH, etc., for the utilization of polyphosphate stabilized foams in various food products.

MATERIALS AND METHODS

All dehydrated foods used in these experiments were commercial products.

Two samples of nonfat milk solids were obtained. One sample, which had a moisture content of 2.5%, was of good quality as indicated by color, odor, and flavor.[c] The other sample, which had a moisture content of 3.5%, was of poorer quality. It had a definite cooked flavor and odor and the color was an off-white. The 2 samples differed markedly in their original whipping ability. The high-quality sample could be whipped without further treatment to a moderate foam volume, stable for approximately an hour. The low quality solids whipped to a much smaller volume and the foam broke down within a few minutes. Webb *(22)* found wide variations in the whipping properties of fresh skim milks and suggested that the preparation of dried skim milk of good whipping ability should involve high heat treatment with an optimum heat treatment for each milk.

Two samples of dried whole egg were used, having 4.0% and 4.5% moisture, respectively.[d] Both had good color and odor and approximately the same whipping ability.

The solvent extracted soybean flour[e] had a moisture content of 8% and a definite raw bean odor and flavor.

Sequestering agents. The polyphosphates used in these experiments were furnished by the Monsanto Chemical Company. Sodium hexametaphosphate $(NaPO_3)_{16}$, a high molecular weight phosphate glass, and crystalline sodium tripolyphosphate, $Na_5P_3O_{10}$, are water soluble and have been widely employed as sequestering agents. Maddrell's Salt, $(NaPO_3)_4$, a sodium metaphosphate of unknown molecular weight, is very limited in solubility. The properties of these compounds have been described elsewhere *(2, 5, 7, 15, 16, 20)*.

The sodium salt of ethylene diamine tetra acetic acid, manufactured by the Bersworth Chemical Co. under the trade name of Versene, forms soluble, stable non-ionic compounds with polyvalent metal ions. It also solubilizes protein, probably through the same mechanisms as are operative with the polyphosphates *(3)*.

The moisture content of the dried products was determined by placing 2 gm. of sample in a flat-bottomed dish and drying in an oven at 100° C. to constant weight.

Foam volume and stability. When determining the effect of added substances on the whipping ability of dehydrated foods, a weighed amount of the powder was added to distilled water with or without added polyphosphates and stirred for 1 minute. The reconstituted product was allowed to stand for 10 minutes and then transferred to the small bowl of a Hamilton Beach mixer and whipped for the required number of minutes at high speed. The volume was measured by transferring the foam to a 400 ml. beaker which had previously been marked in 50 ml. divisions. To measure drainage, the foam was allowed to stand the required length of time and the drip was poured into a graduated cylinder. The foam volume and the amount of draining are reported as percentage of the original volume of reconstituted product.

RESULTS

Whipping Ability of Nonfat Milk Solids

The addition of various sequestering agents. The effect of polyphosphates and other sequestering agents on the whipping ability of nonfat milk solids is shown in Table I. Sodium orthophosphate, sodium tripolyphosphate, sodium hexametaphosphate,

[a] Supported in part by a grant from the Monsanto Chemical Company to the Institute of Industrial Research, Syracuse University.

[b] Present address: Department of Food and Nutrition, The Florida State University, Tallahassee, Florida.

[c] "Starlac," manufactured by the Borden Co., New York, New York.

[d] Armour and Company, Chicago, Illinois.

[e] Nutrisoy XXX Flour, manufactured by Archer-Daniels-Midland Company, Chicago, Illinois.

TABLE 1

The effect of various sequestering agents on the whipping ability of nonfat milk solids

Sequestering agent added (1% in nonfat milk solids)	Increase in volume	Drainage in 20 minutes
	%	%
Control	330	100
Sodium Orthophosphate	370	100
Sodium Tripolyphosphate	750	64
Sodium Hexametaphosphate	750	56
Maddrell's Salt	560	100
Sodium Citrate	660	100
Versene	610	100

Maddrell's salt, sodium citrate, and Versene were added to 10 g. poor quality milk solids and 50 ml. distilled water. The milk powder was reconstituted as described previously and allowed to stand 10 minutes before whipping 3 minutes. The concentration of the sequestering agents in the milk solids was 1.0%. Drainage was measured at the end of 20 minutes. Although all compounds tried gave some improvement the addition of hexametaphosphate and tripolyphosphate resulted in foams with the greatest volume and stability. Increasing the concentration of these polyphosphates to an optimum of 3 to 4 parts in 100 parts of nonfat milk solids did not affect the foam volume but further reduced drainage to approximately 15% in 20 minutes. These foams were considerably more stable than those prepared by treating the same sample of nonfat milk solids with the proportions of edible acid and alkaline sulfates and chlorides recommended in a patent granted to Snelling *(17)*.

A combination of sequestering agents (polyphosphates and citric acid) in the proportions of 4 and 1%, respectively, of nonfat milk solids gave in some cases greater foam volume than that obtained with polyphosphate alone. However, the stability of the foams was usually decreased by the addition of the citric acid and the flavor was undesirably tart, resembling slightly sour milk. There would seem to be little advantage in such a combination except where the acidity is a necessary or desirable part of the final product, as for example in fruit sherbet mixes or fruit whips. In any case, the amount of acid added should not be sufficient to lower the pH below approximately 5.5. At lower pH values foam volume was drastically reduced.

Good quality nonfat milk solids showed greater whipping ability throughout, but here too the polyphosphates improved the foam (Table 2). With either sample of nonfat milk solids, increasing the proportion of solid to liquid in the reconstituted milk produced heavy bodied foams of reduced volume but greatly increased stability.

TABLE 2

Effect of polyphosphates on the whipping ability of high quality nonfat milk solids

Added Polyphosphate (4% of milk solids)	Milk solids in 50 ml. water	Volume increase	Drainage in 2 hrs.
	gm.	%	%
Control	10	560	60
Hexametaphosphate	10	800	50
Tripolyphosphate	10	750	52
Control	31	390	10
Hexametaphosphate	31	420	0
Tripolyphosphate	31	420	0

While these high solid foams are very stable, their usefulness is limited by the chalky taste of the concentrated milk solids and in frozen products by the high lactose content. Since the greater stability is probably to be attributed largely to the increased viscosity, it would seem to be more practical to increase viscosity by addition of small amounts of a thickening or jelling agent rather than by large amounts of the milk solids.

Of several thickening agents tried, an Irish moss derivative, Krim-Kold (manufactured by the Krim-Ko Corp., New Bedford, Mass.), soluble in cold water, proved most successful. The addition of 0.2 to 1.0 part of this vegetable gum to 100 parts of high quality nonfat milk solids and 4 parts of a polyphosphate resulted in foams of high volume and increasing stability. With the larger amounts of vegetable gum the foams were heavy bodied and showed no drainage after 24 hours of standing. Foam volumes decreased slightly with the more viscous solutions.

Sugar, up to 70 parts in 100 parts of nonfat milk solids, could be added to the milk before whipping with very little effect on foaming ability. Further amounts of sugar could be folded or whipped into the foam.

No significant change was noted on the foam volume of controls of good quality milk stored at room temperature and under refrigeration for 5½ months and of poor quality milk solids stored at room temperature for 9 months. The effect of the polyphosphates on foam volume was the same as before storage. The percentage of draining increased slightly except in a few instances.

Utilization of milk foams in food products. The fact that combinations of nonfat solids and polyphosphates constitute a stable meringue powder makes possible the formulation of a wide variety of prepared mixes. A basic meringue powder might consist of the following proportions: 100 parts of nonfat milk solids of initial high foaming ability, 3 parts of hexametaphosphate, 70 parts of sugar and 0.5 part of Krim-Kold. The addition to 100 parts of this mixture of 250 to 300 parts of water results in a solution which may be whipped immediately to a foam stable for many hours, which may be combined with pureed fruits, fruit juice concentrates, cooked starch pastes, etc. Increasing the proportions of water soluble gum and sugar gives a heavier bodied foam. Acidified meringues (1 part citric acid to the basic meringue powder) will set in a slow oven to acceptable meringue shells.

The meringue has several limitations which must be kept in mind in compounding formulas for its use. The fact that the foams become unstable below pH 5.5 is an important point in combining with fruit juices. For example, the addition of sufficient lemon juice to give an acceptable lemon flavored sherbet resulted in a mix of pH 4.4, on the acid side of the isoelectric point of casein. Stable foams did not form and the polyphosphates were detrimental at this pH. Furthermore, the foams could not be combined successfully with cream or whole egg; fat interferes with such protein foams *(6)*.

Whipping Ability of Dried Whole Egg

Dried whole egg meringue with added polyphosphates. To determine the whipping ability of dried whole eggs 24 g. egg powder were reconstituted by making a paste with 24 ml. distilled water and then gradually adding the remaining 48 ml. (total of 72 ml. distilled water). To this 50 g. sugar, 7 ml. distilled water and 8 ml. lemon juice were added *(14)*. This was heated slowly (10 minutes) to 68° C. in a water bath and beaten in a water bath at 75° C. for 10 minutes, using high speed. Volume was measured as before.

TABLE 3

Effect of polyphosphates and storage on foam volume of whole egg meringues

Kind of egg	Storage time (weeks)	Storage temperature	Polyphosphate used	Optimum phosphate in dried egg	Maximum volume increase
		°C.		%	%
Fresh	None	—			560
Dried No. 1	None	—	none		260
	None	—	hexametaphosphate	2.3-3.0	330
	None	—	tripolyphosphate	1.3-2.0	360
Dried No. 2	None		none		220
	None		tripolyphosphate	1.5	380
	13	4	none		220
	13	4	tripolyphosphate	1.5	380
	13	25	none		0
	13	25	tripolyphosphate	1.5	160

The addition of increasing amounts of hexametaphosphate and tripolyphosphate to the dried egg resulted in improved foam volumes up to optimum concentrations different for the 2 polyphosphates (Table 3). Concentrations higher than these optimum ranges caused a slight fall in foam volume. Tripolyphosphate was more effective than hexametaphosphate and acted at lower concentrations. Since dried whole egg is known to deteriorate in solubility, beating power, and flavor during storage *(11)*, aliquots of one sample of egg were stored for 3 months at several temperatures, then whipped with and without tripolyphosphate. Samples stored in the refrigerator showed no deterioration, but those at room temperature could no longer be whipped to a stable foam without the addition of the polyphosphate.

Sponge cakes were prepared using both samples of dried egg and amounts of hexametaphosphate and tripolyphosphate found to be optimum for whole egg meringues. The following formula was used:

144 g. reconstituted egg (36 g. powder and 108 ml. liquid)
75 g. sugar
10.5 ml. distilled water
12 ml. lemon juice
52.5 g. cake flour
45 g. sugar
0.7 g. salt

The meringue ingredients were combined and treated as before. After whipping the meringue was cooled to 40° C. The flour, sugar, and salt which had been sifted together three times, were folded into the meringue. The weight of one cup of batter was recorded and 175 g. of the batter were baked in a rectangular pan, capacity 1100 ml. The cakes were baked at 350° F. (176° C.) for 30 minutes. They were then inverted on racks and allowed to cool before measuring cake volume by rape seed displacement.

The improvement in volume previously shown with the polyphosphates in meringue carried over into the cake batter and baked product (Table 4) indicating the ability of these products

TABLE 4

The effect of polyphosphates on whipping ability of whole dried egg in sponge cake

Kind of egg	Polyphosphate in dried whole egg	Weight of one cup of batter	Volume of cake from 175 g. of batter
		gm.	*ml.*
Fresh		62	980
Dried—4% Moisture	None	117	435
	2.9% Hexametaphosphate	99	660
	4.6% Hexametaphosphate	97	645
	1.5% Tripolyphosphate	84	710
Dried—4.5% Moisture	None	110	525
	2.3% Hexametaphosphate	81	815
	1.5% Tripolyphosphate	74	895

to take a reasonable amount of mechanical abuse. The control cakes were compact and heavy. The polyphosphates in the concentrations used added no detectable flavor to the sponge cakes.

Whipping Ability of Fat-free Soybean Flour

Fat-free soybean flour and derivatives thereof have marked whipping ability *(4, 19, 21)* and have become very useful in the candy and biscuit industries as a substitute for egg albumen or gelatin. To determine the effect of polyphosphates on the aerating power, 4 g. flour were suspended in 50 ml. distilled water *(19)*. This was allowed to stand 10 minutes and then beaten for 8 minutes at high speed. The control showed an increase in volume of 670%. Maximum volume obtained by the addition of the polyphosphates was 760%. Beyond 2.4% tripolyphosphate and 4.7% hexametaphosphate in the flour there was no improvement in volume of the foams. There was some increase in stability even up to 1.2% polyphosphate.

When the amount of flour used was increased to 8 g., the volume was less but the stability was greater. The control, after whipping, increased 500% over the original volume. Maximum volume (600%) was obtained by the addition of 7% polyphosphate to the flour.

DISCUSSION

The improvement in whipping ability of nonfat milk solids, dried whole eggs and fat-free soybean flour brought about by hexametaphosphate or tripolyphosphate may be attributed to the dispersing effect of these compounds on the negatively charged proteins of these dried foods. Their ability to sequester calcium and metal ions which interfere with dispersion and whipping is one factor involved. In addition they can combine directly with protein materials to form more soluble protein-detergent compounds on the alkaline side of the isoelectric point *(10)*. It is possible also that the polyphosphates can bring about a partial hydrolysis of proteins, although there seems to be no direct experimental evidence for this. Protein hydrolysates are known to possess unusual foaming abilities *(12)*.

Attempts to demonstrate greater dispersability of dry milk and egg proteins have been inconclusive. Using the method of Ashworth *(1)* for determination of undispersed residue, the poor quality milk solids used in this study showed a significant reduction from 8.0 to 5.5% insoluble material on addition of optimum amounts of hexametaphosphate, but the good quality milk solids with an initial residue of only 3.4% were not significantly improved in this respect. Custards made with dried egg to which hexametaphosphate was added were smoother and without the thick surface crust of undispersed solids characteristic of custards from the control samples. Tripolyphosphate, in amounts slightly above optimum for best whipping of dried egg (2.3%), prevented setting of the custards.

Whatever the explanation may be, the fact remains that polyphosphates definitely improve the whipping ability of nonfat milk solids, dried whole egg, and fat free soybean flour. They should be particularly useful when added to these foods in appropriate amounts for optimum whipping and combined with gums or other stabilizers, sugar, flavorings, etc. in the form of premixes for specific purposes, such as sweetened toppings, fruit whips, sherbets, sponges, sponge cakes, etc. The results reported in this paper represent only a preliminary, incomplete investigation of the possibilities for use of such mixtures.

SUMMARY

Of a number of sequestering agents added to nonfat milk solids, hexametaphosphate and tripolyphosphate effected the greatest improvement in whipping ability. These polyphosphates also improved the whipping ability of dried whole eggs and soybean flour. The performance of the polyphosphate stabilized milk and egg whips in various food products was investigated.

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Factors in the Selection and Design of a Spray Dryer[a]

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(Manuscript received February 19, 1953)

It is only within the last decade or so that spray drying as an operation in the food industry has grown from a highly specialized tool to a well-accepted unit operation utilized by evergrowing numbers of processing plants throughout the industry. This is shown in Figure 1 wherein the growth of companies engaged in the manufacture of spray drying equipment is indicated at selected intervals starting with one company in 1932 and rising to 13 in 1951.

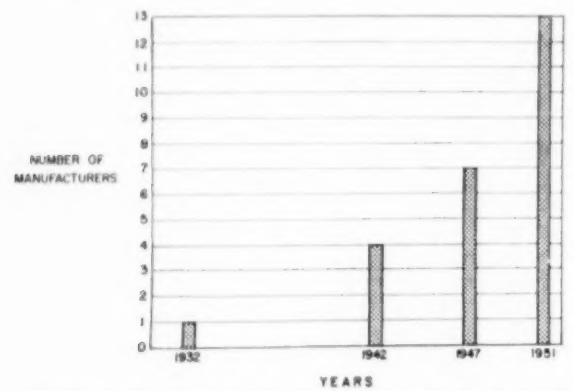

Figure 1. Growth of companies engaged in the manufacture of spray drying equipment.

Spray drying[b] as compared to other drying operations is unique in that it combines a rapid drying cycle, with short holdup times, and delivers a final product that is normally ready for packaging without any further modifications. This paper will attempt to condense some of the fundamentals and offer an outline for an approach to be followed in selecting and designing spray dryers to meet the particular needs of the food industry.

ANALYSIS OF FUNCTIONS AND COST FACTORS

As mentioned, in most cases the function of a spray dryer is to (a) recover a solid in powder form from a solution or suspension by removing the solvent. To achieve this an atomized liquid is exposed to a heated gas flow in a drying chamber. The gas medium has the function of supplying the heat for evaporation and in addition acts as carrier for the evaporated solvent vapor. (b) The second function of a spray dryer is to produce a dried powder having certain definite physical properties, such as density, particle size, color or rate of solution.

This functional analysis serves as a convenient means for defining the 2 major subdivisions of industrial application. Under (a) the object is simply to dry the material without any special emphasis on product appearance or product characteris-

[a] Presented at the Twelfth Annual Meeting of IFT, Grand Rapids, Michigan, June 10, 1952.

[b] In recent years several articles have been published on the subject of spray drying. A very comprehensive treatment of the subject was made by E. Seltzer and J. Settelmeyer in *Advances in Food Research*, **11** (1949). A broad survey of the field was presented by D. A. Smith in *Chem. Eng. Progress*, **45**, (12) (1949). These articles and others are mainly concerned with summarizing the various types of dryers and drying auxiliary equipment. Considerable literature is also becoming rapidly available on studying various phases of spray drying, such as atomization, rates of drying, and dust recovery.

tics. Under (b) the object is to dry the material and obtain specific product properties.

Subdivision (a) is by far the simpler of the two objectives to achieve. In this case a few test runs on a laboratory spray dryer unit are employed to determine if the material can be dried and if any unusual properties can be observed. Positive results on this type of test immediately lead to suggestions for the design of the final dryer. By this time such design factors as *rate of evaporation, nature of solvent, type of liquid* to be atomized and its physical properties, *desired moisture content*, of the product should be known. It should be emphasized that checks should be made on the char or ignition point of the product since that information is needed to determine the maximum gas temperature to be used. From a dryer efficiency standpoint it is best to operate at as high an inlet temperature as possible.

With the above information in hand it is generally best to settle on the final dryer design by close consultation with the manufacturers on the basis of competitive bids. In cases where future increased capacity demands are a possibility, consideration should be given to those items in the drying plant that might become the first "bottlenecks" to such an expansion. Such items as increased gas handling capacity can normally be accomplished without too much expense. On the other hand the overall dimensions of the drying chamber are fixed once the plant is installed and can only be changed by relatively large expenditures and extended shut-down periods.

Table 1 gives an average cost breakdown and emphasizes the relative importance of the various units making up a typical food drying plant. These percentages were arrived at by averaging the costs of several drying plants installed by the General Foods Corporation. Installation cost is included with the exception of that involved in providing housing enclosures that may have been required.

TABLE 1

Cost distribution in a typical food spray drying plant

Unit	% of Cost (Average)
Heating System (Direct Fired):	20%
Furnace, Linings, Burner, Fuel Pump, Expansion Joint, Filters, Insulation	
Atomizing Equipment	4%
Drying Chamber	52%
Product Recovery	10%
Dust Collector, Screw Conveyors, Air Lock	
Air Handling	8%
Fan, Ductwork	
Instrumentation	6%
	100%

Somewhat more difficulty is encountered in our second subdivision (b) where the twofold objectives of drying and obtaining specific product properties are required. Here it is fairly essential to have some knowledge in advance of the specific product requirements. These might include *bulk density, granulation, color, dustiness, desired rate of solution* or other required product performance criteria. Knowing these attributes, pilot plant tests are almost always a prerequisite unless the product to be dried or the performance requirements are well known standards in the trade.

DESIGN FACTORS

Considerable time and expense will be saved by an inspection of the check-off list presented in Figure 2. The prime objective of this list is to permit a narrowing down of alternate designs.

DIRECTION OF AIRFLOW (WITH RESPECT TO SPRAY)	TYPE OF ATOMIZATION	TYPE OF AIR MOTION	METHOD OF HEATING AIR	TYPE OF AIR HANDLING SYSTEM	OPERATIONAL CONTROL	METHOD OF PRODUCT SEPARATION
VERTICAL UPFLOW COUNTER CURRENT	TWO FLUID NOZZLES	STRAIGHT FLOW IN VERTICAL DIRECTION	INDIRECT HEAT	SINGLE EXHAUST FAN	INLET TEMPERATURE	EXTERNAL
VERTICAL UPFLOW CONCURRENT	CENTRIFUGAL DISCS	TURBULENT FLOW IN VERTICAL DIRECTION	DIRECT HEAT OIL GAS	BALANCED SYSTEM USING FAN AT INLET AND OUTLET OF DRYER	OUTLET TEMPERATURE	INTERNAL
MIXED FLOW	SPRAY NOZZLES	ROTARY MOTION DUE TO TANGENTIAL AIR INLETS OR ANGULAR VANES		SINGLE INLET FAN	FLOW RATE	MIXED
HORIZONTAL CONCURRENT					PRESSURE	
VERTICAL DOWNFLOW CONCURRENT					COMBINATIONS OF ABOVE	

Figure 2. Check-list of design characteristics.

Column 1 of Figure 2 requires some amplification. In view of the fact that most products dried in the food industry are heat sensitive, the *vertical counter-current type* of dryer can in most cases be eliminated, because the finished dried product comes in contact with the hottest gas and the possibility of charring and overheating exists.

The *vertical upflow concurrent dryer* is normally useful in only those cases where a relatively fine powdery quick drying product is handled. Its action depends largely on the air stream to keep the powder suspended during drying and therefore fairly high velocities are needed if coarse granulation is required. Its main advantage is that it is small in size and quite compact.

The *mixed flow* type of dryers as typified by the Swenson, Majonnier or Niro dryer usually imparts some horizontal motion to the air to obtain efficiency and capacity advantages.

Their use is quite often restricted to products that are not thermoplastic and are of a rapid drying nature. Due to the horizontal air motion the velocity of the atomized particles towards the walls is accelerated—frequently resulting in excessive product build-up on the dryer walls. Products that are fragile in the granular state might also suffer undue breakage.

Horizontal concurrent dryers have been used with good success in the dairy industry. Most of the conventional designs, however, offer limitations on the coarseness of granulation that can be obtained, because the path of the wet particle trajectory is limited.

The vertical concurrent downflow dryer has the advantage of fairly broad flexibility since in this case height and diameter are the only items affecting product limitations. Its main disadvantage is that it usually results in fairly large space requirements.

All of the foregoing types of airflow can be quickly visualized in Figure 3.

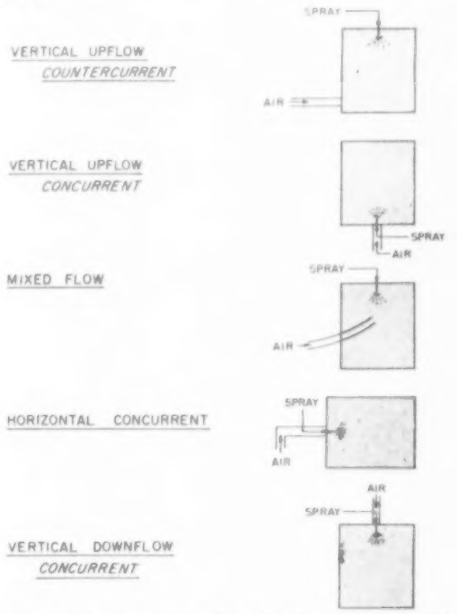

Figure 3. Direction of airflow (with respect to spray).

Returning to Figure 2 it will be noted that in Column 2, types of atomization are presented. Atomization might be considered the heart of the drying plant. By setting atomizing conditions the product characteristics are definitely bracketed and can only be changed within discrete limitations by changing some of the other dryer variables.

Only on rare occasions are *two fluid nozzles* used in commercial dryers in the food industry. Their use can be justified when either extremely fine particles are required (e.g. less than 10 microns) or when the product to be dried is extremely difficult to atomize, such as viscous colloidal solutions.

Centrifugal atomizers have the advantage of being able to handle slurries containing relatively coarse particles without

excessive danger of "plug-ups." Another possible advantage of this type of atomization over spray nozzles is that less mechanical shear is exerted on the fluid which is sometimes desirable from the product quality standpoint.

Variability in the feed solution can be compensated for within limits by varying the speed of rotation. For extreme variations a different bowl has to be installed which normally results in some shutdown time. These discs[*] rotate at speeds up to 50,000 r.p.m. and therefore should be dynamically balanced at regular intervals to result in safe operation. Most atomizing discs have a tendency to act as an air pump and therefore their action results in some product aeration which can be harmful from either the product quality or physical property standpoint.

Spray nozzles are still the most universally used means of atomization. If made of steel, brass, or stainless steels, they are quite inexpensive and simple to replace. If used on abrasive materials, the useful life of a nozzle can be increased by changing to a harder material of construction such as tungsten carbide, sapphire or by altering the hardness of stainless steel by nitriding it. An enormous range of atomization and capacity can be obtained by varying the feed pressure on the nozzle and the nozzle combination of either the core, the orifice, the body or the head. Spray patterns can be varied from a hollow cone to a fulljet in addition to a wide range of possible spray angles.

Considerable work is currently in progress to study atomization in an attempt to correlate particle size distributions with the physical characteristics of the fluid and the spray nozzles.

Further efforts are needed in the area of spray nozzle specifications. Tolerances presently maintained by most of the spray nozzle manufacturers are not close enough to cover the needs of a spray drying operation where close particle size control is required.

Table *2* shows capacity tests made on a series of new hollow cone nozzles ordered under manufacturing specifications.

TABLE 2

Capacity tests of spray nozzles

Nozzle No.	Rate GPM
1	0.731
2	0.915
3	0.728
4	0.851
5	0.769
6	0.783
7	0.793
8	0.776
9	0.702
10	0.774
11	0.831
12	0.700
13	0.767
14	0.775
15	0.737
16	0.761
17	0.775
18	0.920
19	0.771
20	0.736
21	0.765
22	0.781
23	0.797

Mean = 0.777
Range = 0.229 GPM

Using these numbers as an index of nozzle uniformity it can readily be seen that this type of variation cannot lead to an accurate quality control of the product.

Column *3* of Figure *2* lists types of air motion. The main factors to consider in evaluating the various alternates are product-sticking tendencies and possible particle breakage. A tendency for either one of these properties would make a straight flow non-turbulent air flow more advantageous.

The main advantage of air turbulence, brought about by either high velocities or by introducing horizontal velocity components, is more intimate mixing of the hot air with the liquid resulting in more rapid drying and subsequently less dryer height requirements.

Under column 4 of Figure *2* methods of heating the air are presented. This is strictly a question of economics and product quality. Economics are largely in favor of direct heat, and it should be used whenever no danger exists of the products of combustion affecting the product quality. It has been our experience that if proper combustion takes place in a well designed furnace with a well-balanced air system no off odors or flavors due to products of combustion are imparted to the product. Selection of fuel depends largely on the locality.

In column 5 of Figure *2* types of air handling systems are shown. Driers designed to use a single exhaust fan normally operate under a slight vacuum in the drying chamber. The magnitude of the vacuum depends on the restrictions imposed on the air flow ahead of the drying chamber and the pressure drop across the air distribution systems. The disadvantage of this type of design is twofold. It often leads to a more expensive dryer design to withstand the vacuum and secondly some air leakage into the drying system will usually occur thereby decreasing the overall plant efficiency. This efficiency decrease takes place because some of the heat input has to be utilized to heat up any air leakage to the temperature of the exhaust gases, thereby decreasing the amount of heat available for evaporation. An added disadvantage of excessive air leakage in a single exhaust fan system is a noticeable capacity decrease due to the fact that less heated air is drawn into the tower. A system of balanced fans with a blower at the air inlet and an exhaust fan designed to maintain a static close to 0" in the dryer overcomes these difficulties. Pressure conditions in the drying chamber can be controlled to within 0.01" of H_2O by installing inexpensive and automatic control systems.

Operational controls are listed in column 6 of Figure *2*. The need for instrumentation and automatic controls depends entirely on the process and product demands. A system of outlet temperature controls is often sufficient to control the product moisture content. Feed rate or atomizing pressure control is often advisable in cases where constant product granulation is required. An added instrumentation feature that has often aided in the production control of our drying plants is the use of a wattmeter on the fan motor to indicate the airflow at all times. This type of instrument makes it easy to spot variations in airflow which in turn affect product quality and drying capacity.

Column 7 lists methods of product separation. The separation of powder from the air stream can be accomplished by designing the drying chamber in such a manner that some fraction of the product will be separated in the drying chamber proper. This is normally accomplished by either imparting rotation to the airflow or by some mechanical means of baffling the air to cause a change in direction of the air stream. Product separation in the tower is normally made use of in cases where subsequent product handling might cause excessive breakage. Separation of this type will invariably result in a particle size fractionation obtaining a coarse product from the dryers and a much finer product from subsequent separation equipment.

In those cases where particle size and contact time in hot air are of limited importance, the recommended system of product recovery is to pass the powder and air stream to a separate powder recovery system. The advantage of this system is that a single product stream is obtained and it also lends itself to more uniform and possibly more complete drying.

Powder recovery systems have to be carefully selected on the basis of collection efficiency and pressure drop. In those cases where dust losses to the atmosphere are prohibitive from either an economic or a nuisance standpoint, recourse to a secondary collector such as a bag house, a wet collector or an Aerodyne should be taken.

FINAL STAGE—THE PILOT PLANT TEST

Having considered all of the above points the preliminary outline of a design can be obtained. The process should then be tested on pilot plant equipment, choosing the type of pilot plant dryer on the basis of the above considerations. The pilot plant dryer should be

[*] Recent work (Adler and Marshall, *Chem. Eng. Progress*, **47**, [10] 515, 1951) has shown that results obtained from a variety of spray-disc designs are comparable.

large enough so that the type of atomization used will be comparable to that used in the production model with the sole exception of capacity. Capacity scale-ups exceeding a 1 to 30 ratio should rarely be attempted. A one to ten scale-up from pilot plant data to plant capacities will lead to more conservative results. An ideal situation for extrapolating pilot plant data on atomization is to perform the tests on a given spray nozzle and to design the production unit so that the desired capacity is obtained by using several nozzles of the same type.

In the case where a centrifugal atomizer is used in pilot plant tests it is important to retain the same centrifugal force in the final scale-up. It is also advisable to aim for the same liquid loading per square foot of disc surface in designing the atomization system for the plant unit. Correlations on the effect of feed rate variations on centrifugal atomization indicate the drop size to vary directly as the feed rate to the 0.2 power. (See Friedman, Gluecker, and Marshall, *Chem. Eng. Progress*, **48**, [4] 1952.)

Considerable confusion exists in designing the dimensions of the drying chamber. The objective is mainly to make the tower big enough to dry the largest droplets or by maintaining a minimum particle hold-up time. Assuming constant atomization in both the pilot plant and plant dryers the diameter of the tower can be designed by maintaining constant linear air velocities.

Several empirical relationships have been developed to arrive at the volume requirements of a spray tower:

$V = Q\Theta$ V = Chamber volume (cubic ft.)
Q = Average volumetric gas rate (cubic ft./min.)
Θ = Overall average contact time (min.)

To use this equation some estimate of contact time has to be available. This value can be obtained from pilot plant data or it can be approximated by empirical correlations.[4] Either method will at best result in an approximation of the Chamber Volume without giving any information on the relative dimensions of height vs. diameter. Presently this information can only be obtained by applying experience factors to the design which are always specific for a given product.

The particle size of the final product as well as the amount of mixing obtained between the air and the fluid have a great effect on the tower sizes. Table 3 illustrates this point.

TABLE 3

Lbs. H_2O evaporated/hr./ft.^{3} dryer space/at a ΔT of 200° F.

Type of Product	Lbs.
Fine Particles (turbulence)	1.4
Fine Particles (no turbulence)	1.0
Coarse Particles (no turbulence)	0.2 or less

To put this part of the design on a more scientific basis considerable work will have to be done on studying rates of drying of drops for a variety of materials. A combination of drying rate studies with a knowledge of particle trajectories (See Lapple and Shepherd, *Ind. Eng. Chem.*, **32**, 605, 1940) will eventually lead to a systematic spray dryer design.

[4] See G. G. Brown & Associates, *Unit Operations*, 1950, J. Wiley & Sons, New York, page 564.

As a by-product of any studies on rates of drying will come some fundamental knowledge on the mechanism of the drying of a droplet. Some of the work carried on at our laboratories showed a striking difference in the drying behavior of a synthetic detergent formulation as compared to a roasted wheat extract.

From the following figures it can be seen that a droplet of a synthetic detergent formulation actually expands in the course of drying (Figure 4). A droplet of roasted wheat extract dried under similar conditions shrinks in the course of drying (Figure 5).

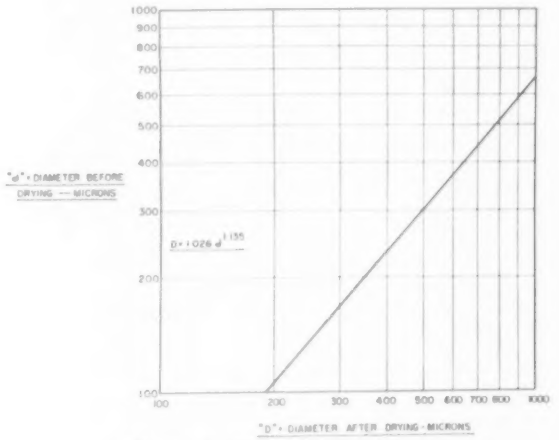

Figure 4. Detergent formulation.

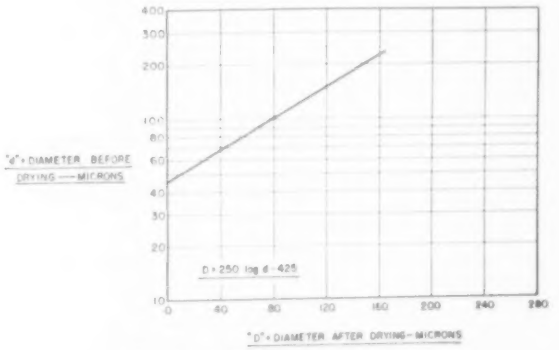

Figure 5. Roasted wheat extract.

Further studies along these lines should eventually lead to a series of correlations that will predict product granulation knowing the properties of the feed material and drying conditions.

CONCLUSION

The applied "know-how" of spray drying and the design of spray dryers has progressed at a much more rapid rate than the development of the theoretical concepts underlying the operation. The food industry having taken a very aggressive part in the development and application of spray drying to their products and processes has much to gain in furthering the required fundamental studies. This work will assure a maximum return on the investment and will result in improved product quality and uniformity.

Effect of the Removal of Glucose by Enzyme Treatment on the Whipping Properties of Dried Albumen[a]

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(Manuscript received February 12, 1953)

A procedure is described for the use of a commercial enzyme preparation in the production of a glucose-free albumen on a laboratory scale. The functional properties of the rehydrated enzyme-treated albumen were determined. The use of an enzyme complex consisting of glucose-oxidase and catalase appears to hold promise as a method for removal of glucose prior to the drying of egg white. Under the experimental conditions employed, the treated dried albumen rehydrated readily and had no off odors or flavors. The angel cakes made with the rehydrated enzyme-treated egg white compared favorably in volume, texture and flavor with angel cakes made with frozen egg white.

It is necessary that glucose be removed from liquid egg white prior to drying in order to produce a stable dried albumen. Various methods have been investigated in an effort to obtain a satisfactory and practical process. In the industry, a "spontaneous" fermentation of egg white is commonly used for removing the glucose; however, this method has several disadvantages. The poor leavening power of rehydrated "spontaneous" fermented albumen makes it unsuitable for use in high quality angel food cakes. Another method that is used commercially is yeast fermentation of egg white previous to drying. Carlin and Ayres *(2)* reported that yeast-fermented egg white does not have an objectionable off-odor and retains all the properties of fresh albumen, particularly whipping properties. However, they found that angel cakes made with this dried egg product had a characteristic after-taste which some people were able to detect.

In 1951 an enzyme complex consisting of glucose oxidase (a dehydrogenase) and catalase was produced commercially in quantity; interest developed in its application in the removal of glucose from egg white. Accordingly a study was planned to investigate: (a) the possibility of using this enzyme complex in the production of a glucose-free dried albumen, and (b) the effect of the enzyme treatment on the whipping properties of the dried albumen. Quite recently other workers have given a report on applying "deoxygenase" to the desugaring of commercial size batches of egg white *(1)*.

An advantage of the use of an enzyme preparation appears to be that it overcomes some of the criticisms that might be engendered by introducing an intact cell inoculum, such as excessive growth of microorganisms or development of off odors or flavor. Also, with an enzyme specific for glucose there is less likelihood that proteolysis of the egg white will result.

Specifically this report presents the details of the enzyme treatment used to produce a glucose-free dried albumen and the results obtained when angel cakes were made to test the whipping properties of this glucose-free albumen.

EXPERIMENTAL PROCEDURE

The eggs used in this study were 3 days old; they were obtained from the Iowa State College Poultry Farm. Four trials were made during the fall and winter of 1951; approximately 15 dozen large-sized eggs (5-6 liters of albumen) were broken for each trial. The procedure used to obtain blended egg white was similar to that described previously by Carlin and Ayres *(2)*. After blending, the albumen was pooled and then divided into 3 parts. Two-thirds of the pooled sample was enzyme-treated, the remainder was frozen in lots of 260 ml. to be used for the control angel cakes.

For those portions of albumen from which the glucose was to be removed, a commercial liquid enzyme complex[b, c] consisting of glucose oxidase and catalase was used. The liquid albumen was divided into 2 equal parts. To favor optimum enzyme activity, sufficient acid was added to each of the portions of albumen so that the pH was adjusted to 7.0; to one part of the albumen, 5-6 ml. of 3 N hydrochloric acid was added, and to the other 8-10 ml. of 40% tartaric acid was added per liter. The amount of acid necessary was dependent upon the amount of dissolved carbon dioxide remaining in the albumen at the time of adjustment. A 0.1% level of the enzyme solution supplied commercially was added to the liquid egg white; the temperature during the treatment period was maintained at 25° C. (77° F.). The total amount of hydrogen peroxide added was equivalent to 6 ml. of 30% hydrogen peroxide per liter. The hydrogen peroxide was diluted to permit its introduction in one-fourth or one-half ml. amounts each 30 minutes throughout the treatment period (about 10 hours). It was necessary to exercise care while adding the hydrogen peroxide to prevent excessive foam. The addition of very small amounts of hydrogen peroxide at frequent intervals resulted in the least foaming.

At 30-minute intervals the pH level was determined and the 15-minute browning test *(1)* was used to check residual glucose. The product was considered to be glucose-free when no color developed in the test sample of dried egg white. Also, at that time the pH had reached its minimum value.

At the sugar-free stage, the albumen was pan-dried. Two hundred and fifty ml. of egg white was poured onto aluminum trays (16" x 11½" x 1") to a depth of 3/16". These trays were placed under a battery of infra-red heat lamps, care being taken to keep the temperature of the albumen below 40° C. (104° F.) until a "heavy skin" formed on the surface. The lights were then turned off and drying was completed with the aid of a fan moving air heated to about 27° C. (80° F.). After drying, the enzyme-treated dried egg white was placed in a gas-tight bottle and stored in the refrigerator at 1.1° C. (34° F.).

Angel cakes were made in order to test the whipping properties of the dried egg. The formula and procedure used for the angel cakes has been described previously *(2)*. In the control angel cakes made with frozen egg whites, 0.90 g. of cream of tartar were used. The pH of the rehydrated albumen was lower

[a] Journal Paper No. J-2249 of the Iowa Agricultural Experiment Station, Ames, Iowa. Project Numbers 1026 and 970.

[b] Kindly supplied by the Vitazyme Corp., Chicago, Illinois. Sold as the patented product DEOXYGENASE.

[c] Mention of commercial products used in scientific work is often essential; their indorsement by the authors, or by the Institute of Food Technologists should not be inferred.

than that of the frozen egg white; therefore, in the angel cakes made with the enzyme-treated dried albumen, the amount of cream of tartar used was varied (i.e., 0.00 g., 0.23 g., 0.45 g., 0.67 g., and 0.90 g. were the amounts used).

A record was made of the time required to beat the meringue to the "soft peak" stage. The specific gravity of the meringue and batter was determined by weighing a portion of each in a container of known volume.

One hundred and ten grams of batter were weighed into a baking pan (2.75" x 3.5" x 5.5") of known volume and baked at 175° C. (350° F.) for 25 minutes in a Despatch Rotary Oven (Model-150-R). After baking, the cakes were inverted, cooled and stored overnight at 22° C. (71° F.). The cake volume was measured by the seed displacement method; the results are reported on the basis of 100 g. batter. The pH of all angel cakes was determined.

The results that were obtained in the 4 separate trials were similar; hence the data were pooled and averaged.

A panel of 7 carefully selected and trained judges was used to evaluate texture and flavor of the angel cakes. Triangle or "odd sample" tests and ranking were the methods employed for recording their decisions.

RESULTS AND DISCUSSION

Enzyme-treated pan-dried albumen obtained under the conditions of this experiment rehydrated readily and was free of any objectionable odor or flavor. It showed no browning when held at 120° C. (248° F.) for 2 hours *(3)*.

Grewe and Child *(6)* have shown that potassium acid tartrate is a necessary ingredient required to produce a fine-grained, white angel cake; and that citric, malic, and tartaric acid had the same effect on the color and grain of the cake as did potassium acid tartrate. Later, in a study on the effect of acid on egg white foams, Barmore *(2)* found that not all acids produced equivalent effects in stabilizing foam, potassium acid tartrate having the most desirable effect of the three acids used —acetic, citric, and potassium acid tartrate.

Previous research in this laboratory [Carlin *(5)*] indicated that 0.90 g. of cream of tartar in the particular formula used (61 g. of egg white) resulted in angel cakes of optimum texture, volume, color and flavor. The data for angel cakes made with frozen egg white and varying amounts of cream of tartar are given in Table 1. When smaller amounts of cream of tartar were used, the cakes were coarse in texture, yellow, and had lower volume; when larger amounts of cream of tartar were used, the volume of the angel cakes was lower and the taste was noticeably acid.

TABLE 1

Effect of amount of cream of tartar in the angel cake formula on volume, pH, and flavor scores of cakes made with frozen egg white

Amount of cream of tartar	Beating time of meringue	Volume of cake	pH of cake	Flavor score[a]
grams	*seconds*	*ml. (100 g. batter)*		
0.00	19.7	540	8.6	6.4
0.45	19.4	608	7.3	7.1
0.90	20.2	626	6.3	6.1
1.35	19.2	601	4.6	7.1
1.80	19.7	582	4.3	5.4
2.25	19.5	561	4.1	4.3

[a] Score of 10 is maximum; averaged for 6 judges.

No research has been reported on the extent to which an acid used to lower pH of liquid albumen prior to removal of glucose might affect the whipping properties of the rehydrated albumen and whether any adjustments in the angel cake formula were needed.

Hydrochloric or tartaric acid was used in this study to lower the pH of the raw liquid albumen before the enzyme was added; therefore, the pH of the rehydrated albumen (8.1) was lower than that of the frozen control albumen (9.0). Two questions that might be raised are: (a) does the kind of acid used to lower the pH of the liquid albumen affect the whipping properties of the rehydrated glucose-free albumen, and (b) to what extent can this acid replace the necessary amount of potassium acid tartrate in the angel cake formula.

The 2 samples of rehydrated egg whites were similar with respect to the properties tested (beating time and specific gravity of meringue, pH, volume, and flavor of angel cake) whether hydrochloric acid or tartaric acid was used to lower the pH of the raw liquid albumen (see Tables 2 and 3, Figure 1). However, the presence of these acids in the dried albumen contributed to the acidity of the angel cake and, consequently, less cream of tartar was required to produce egg white foams of desired stability and tender cakes with satisfactory texture, volume, flavor, and color. Maximum volume was obtained in the angel cakes made with rehydrated albumen when 0.23 g. of cream of tartar was used in the

TABLE 2

Effect of amount of cream of tartar in angel cake formula on beating time and specific gravity of meringue and on pH of cake

Egg sample used	Amount of cream of tartar used	Beating time of meringue		Specific gravity of meringue		pH of cake	
		Tartaric[a]	HCl[a]	Tartaric[a]	HCl[a]	Tartaric[a]	HCl[a]
Enzyme treated dried albumen	*grams*	*seconds*					
	0.00	23.1	24.5	0.21	0.21	7.3	7.3
	0.23	20.9	21.1	0.22	0.22	6.4	6.5
	0.45	21.5	22.1	0.22	0.22	5.7	5.6
	0.67	21.8	22.6	0.22	0.22	5.1	5.1
	0.90	22.4	22.3	0.22	0.22	4.9	4.8
Control	0.90	20.3		0.19		5.7	

[a] Acid used to adjust pH of albumen prior to enzyme treatment.

TABLE 3

Results of triangle tests in which a panel of seven judges compared the flavor of various samples of angel cakes made with rehydrated or frozen egg whites

Cakes compared		Flavor difference[a]
Frozen egg white (control 0.90 g. Cream of Tartar)	Rehydrated albumen (HCl[b]) 0.00 g. Cream of Tartar	*
	Rehydrated albumen (HCl[b]) 0.23 g. Cream of Tartar	ns
	Rehydrated albumen (HCl[b]) 0.45 g. Cream of Tartar	ns
	Rehydrated albumen (HCl[b]) 0.67 g. Cream of Tartar	ns
	Rehydrated albumen (HCl[b]) 0.90 g. Cream of Tartar	**
Frozen egg white (control 0.90 g. Cream of Tartar)	Rehydrated albumen (Tartaric[b]) 0.00 g. Cream of Tartar	**
	Rehydrated albumen (Tartaric[b]) 0.23 g. Cream of Tartar	ns
	Rehydrated albumen (Tartaric[b]) 0.45 g. Cream of Tartar	ns
	Rehydrated albumen (Tartaric[b]) 0.67 g. Cream of Tartar	ns
	Rehydrated albumen (Tartaric[b]) 0.90 g. Cream of Tartar	*
Rehydrated albumen (HCl[b]) 0.23 g. Cream of Tartar	Rehydrated albumen (Tartaric[b]) 0.23 g. Cream of Tartar	ns
Rehydrated albumen (HCl[b]) 0.45 g. Cream of Tartar	Rehydrated albumen (Tartaric[b]) 0.45 g. Cream of Tartar	ns

[a] Acid used to adjust pH of liquid albumen prior to enzyme treatment. The sign ** indicates results significantly different at the 1% level; the sign * indicates results significantly different at the 5% level; the sign ns indicates results not significantly different.

formula; these cakes had a volume only 3% lower than that of the control cake (Figure 1). However, the pH of the angel cakes made with rehydrated albumen and 0.23 g. of cream of tartar was higher (6.3) than the pH of 5.3 for the control angel cakes (Figure 2).

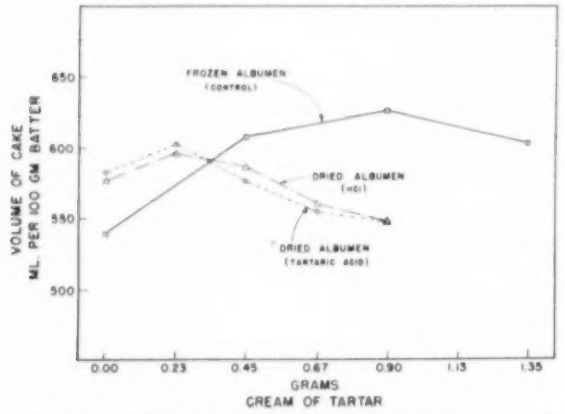

Figure 1. Effect on the cake volume of variation in amount of cream of tartar in the angel cake formula.

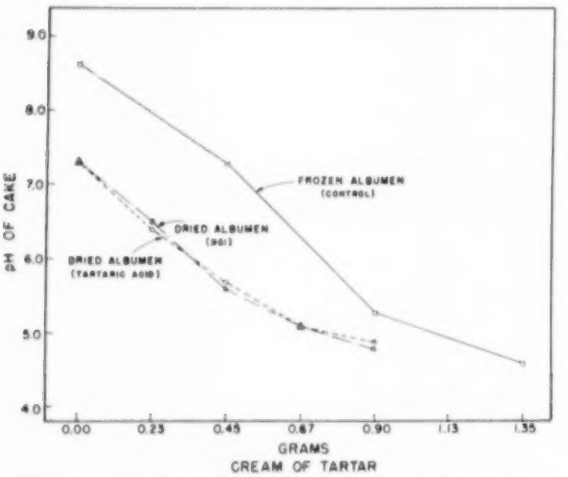

Figure 2. Effect on pH of variation in amount of cream of tartar in the angel cake formula.

A panel of 7 judges carefully selected and trained was given a series of triangle tests in which the various angel cakes made with frozen and with rehydrated enzyme-treated egg white were evaluated for flavor. The 12 comparisons that were made are listed in the left-hand column of Table 3. The results of the subjective evaluation indicated that the judges were unable to distinguish between the flavor of the control angel cakes and that of cakes made with rehydrated enzyme-treated albumen that contained 0.23 g., 0.45 g., or 0.67 g. of cream of tartar in the formula. Also, the type of acid used to adjust the pH of the albumen at the time of treatment was not found to produce a significant difference in the flavor of the angel cakes made with the rehydrated enzyme-treated albumen (Table 3, last 2 comparisons in left-hand column).

In the ranking tests, the judges preferred the texture and flavor of the angel cakes made with rehydrated enzyme-treated albumen and 0.23 g. or 0.45 g. of cream of tartar in the formula to that of cakes containing lower or higher levels of cream of tartar. Apparently the acid used to adjust the pH of the liquid albumen prior to the enzyme treatment reduced the amount of cream of tartar required for optimum cake flavor.

SUMMARY

An enzyme preparation was used for the production of a glucose-free dried albumen, and angel cakes were made to test the whipping properties of the rehydrated egg white. Under the conditions employed, enzyme-treated pan-dried albumen rehydrated readily and was free of any objectionable odor or flavor.

Results indicated that the rehydrated albumen was similar in the properties tested (beating time and specific gravity of meringue, pH, volume, and flavor of angel cake) whether hydrochloric or tartaric acid was used to lower the pH of the raw liquid egg white before the enzyme was added.

The angel cakes made with rehydrated enzyme-treated albumen and 0.23 g. of cream of tartar in the formula compared favorably in volume and texture to the control cakes. Subjective evaluation indicated that there were no significant differences in flavor between the control angel cakes (made with frozen egg white and 0.90 g. cream of tartar in the formula) and cakes made with rehydrated enzyme-treated egg white when 0.23 g. or 0.45 g. of cream of tartar was used in the formula.

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The Effect of Sweetened and Unsweetened Foods on Stainless Steel Cooking Utensils

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(Manuscript received December 15, 1952)

The corrosive effects of acid foods, with and without added sugar, were determined on stainless steel cooking utensils. The addition of sugar to acid foods causes a sparing effect on the corrosion of the utensils.

In a previous study in this laboratory, Poe and Nyholm *(3)* determined that acid foods had very little effect on stainless steel cooking utensils. Also, these investigators found in some instances that the juices highest in sugar content dissolved less iron and chromium from the cooking utensil. Similarly, the action of some dilute organic and inorganic acids on stainless steel strips was investigated *(2, 4)*. Of the acids used, oxalic acid in normal concentration was the only organic acid which had any great effect on the stainless steel strips when they were boiled in this acid for 30 minutes daily for a period of ten weeks. In the present research the effects of the same fruit juices, sweetened and unsweetened, were tried on different brands of stainless cooking utensils.

METHODS AND PROCEDURE

All of the fruit juices used in this research were unsweetened canned juices. The stainless steel utensils used were standard stock varieties and were furnished by different manufacturers. The composition of the stainless steel used for the manufacture of the cooking utensils is approximately 18% chromium, 8% nickel, and 74% iron.

The juice was measured into each pan and heated to the boiling point over an open flame. The covered pans then were transferred to a steam bath, and the contents were allowed to simmer for exactly one-half hour. The original volume was restored by the addition of distilled water, and the cooked juices were placed in stoppered flasks and stored in the refrigerator until analyzed. With the first juice used, separate cookings were conducted for the sample of pure juice; the juice containing 5%, 10%, and 20% sucrose; and for the juice containing 10% glucose. With all subsequent samples of juice, tests were made only with the original juices and with those containing 10% added sucrose.

An aliquot of each cooked juice was measured into platinum dishes, evaporated to dryness on a steam bath, charred and ashed in the electric furnace at a temperature of approximately 650° C. The ash was in all instances analyzed for iron, and, in some instances, for chromium and nickel. Snell *(5)* colorimetric methods were used for the determination of iron, chromium, and nickel.

EXPERIMENTAL RESULTS

The first set of experiments consisted of determining the effects of added sucrose and glucose on the corrosive effects of grapefruit juice on stainless steel utensils. The results of these experiments are given in Table 1. The amount of iron that is dissolved from the utensils by the grapefruit juice varies inversely with the amount of sugar in the juice. Less than one-half of the amount of the iron is dissolved with juice containing 20% of sucrose as with the original juice. Sucrose and glucose in 10% amounts show approximately the same retarding effects.

TABLE 1

Iron dissolved from stainless steel utensils by grapefruit juice containing different percentages of sugar

Sucrose	1*	2	3	4	5	6	Average
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
0	2.3	2.7	2.6	2.6	3.3	1.8	2.55
5	1.2	2.4	2.4	2.5	2.4	1.6	2.08
10	0.9	2.2	2.1	1.8	1.8	1.0	1.63
20	0.7	2.1	1.2	0.9	1.6	0.6	1.18
10†	1.1	2.3	2.0	1.6	1.3	0.9	1.54

* Numbers refer to different brands of utensils.
† Glucose.

In Table *2* are shown the results of the effect of corrosion by the original juices and those containing 10% of added sucrose. In each instance the sweetened juice dissolves much less iron from the utensils than does the unsweetened juice. The average results for all the utensils and juices show *3.69* p.p.m. of iron for the original juices and 1.68 p.p.m. for the sweetened juices, or over 54% reduction in corrosive effect by the sweetened juices. There is little uniformity in the action of a given juice on the different individual utensils. Utensil number *3* showed the greatest corrosive effect and utensil number 1 the least effect. The results listed under the heading "Blank" are the amounts of iron present in the original juices.

Table *3* gives data concerning the amount of chromium which is dissolved from stainless steel utensils by sweetened and unsweetened juices. The amounts of chromium dissolved are so small that any comparison on the effects of added sugar is of little value. However, the presence of sugar retards, to some extent, the corrosive effects of the juice on the utensils.

In all instances, where sugar had been added to the juices, the analytical results were corrected to eliminate the diluting

TABLE 2

Iron dissolved from stainless steel utensils by sweetened and unsweetened fruit juices

Kind of juice	Blank	1*	2	3	4	5	6	Average
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Unsweetened grapefruit	4.6	2.3	2.7	2.6	2.6	3.3	1.8	2.55
Sweetened		0.9	2.2	2.1	1.8	1.8	1.0	1.63
Unsweetened pineapple	3.7	1.9	2.1	1.8	1.4	2.4	1.3	1.80
Sweetened		1.2	1.2	0.8	1.3	1.5	0.5	1.02
Unsweetened orange	5.0	3.0	7.0	4.5	2.8	2.6	0.7	3.43
Sweetened		0.1	2.2	1.3	0.0	2.2	0.5	1.38
Unsweetened prune	50.0	2.0	4.0	14.8	8.3	9.2	6.9	7.03
Sweetened		1.8	0.0	6.3	2.8	2.7	4.8	3.07
Unsweetened pear	80.1	2.6	5.9	7.2	1.4	3.6	1.1	3.63
Sweetened		2.0	0.0	2.1	0.6	2.1	1.0	1.30
Averages								
Unsweetened juices		2.36	4.34	6.18	2.70	4.22	2.34	3.69
Sweetened juices		1.20	1.12	2.92	1.30	2.02	1.52	1.68

* Numbers refer to different brands of utensils.

TABLE 3

Chromium dissolved from stainless steel utensils by sweetened and unsweetened fruit juices

Kind of juice	1*	2	3	4	5	6	Average
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Unsweetened orange	0.45	0.32	0.20	0.10	0.13	0.18	0.23
Sweetened	0.15	0.10	0.13	0.12	0.12	0.06	0.11
Unsweetened prune	0.20	0.20	0.18	0.08	0.36	0.12	0.18
Sweetened	0.16	0.11	0.10	0.05	0.32	0.05	0.15
Unsweetened pear	0.10	0.31	0.18	0.18	0.31	0.20	0.20
Sweetened	0.12	0.25	0.05	0.10	0.25	0.18	0.17
Averages							
Unsweetened	0.25	0.28	0.19	0.12	0.27	0.17	0.21
Sweetened	0.14	0.15	0.09	0.09	0.23	0.10	0.12

* Numbers refer to different brands of utensils.

effect of the sugar, so the p.p.m. referred to in the tables are on the basis of milligrams of metal dissolved per kilogram of pure juice after correcting for added sugar.

A study of the tables shows that the addition of sugar to fruit juices has a sparing effect on the corrosion of stainless steel utensils. We noted that the amounts of iron, nickel, and chromium dissolved were not in the same proportions as these elements existed in the stainless steel used in the manufacture of the utensils. No measurable amount of nickel was dissolved by any of the juices.

In order to determine whether or not the corrosive effect had any relationship to the amount of acid present, titrations were made for acidity on each juice. The results are reported in Table 4 in ml. of 0.1 N NaOH required to neutralize 100 g. of juice. In studying Tables 2 and 4, it is discovered that there is little relationship between acidity and corrosive effect. The two juices, prune and pear, showing the least amounts of titratable acidity, dissolved the largest amounts of iron from the utensils.

TABLE 4

Acidity of unsweetened fruit juice

Juice	0.1 N NaOH required for 100 g. of juice
	ml.
Grapefruit	239.8
Orange	184.8
Pineapple	130.9
Prune	82.5
Pear	62.7

These two juices also have a slightly greater amount of natural sugar than do the other three juices used. In a previous investigation *(1)* with aluminum utensils, the acidity of the fruit juice and the corrosion correlated much more closely.

CONCLUSIONS

1. The acid fruit juices tested show a slight corrosive action on the stainless steel utensils.
2. The acidity of the juice and the corrosive effect show little relationship.
3. Unsweetened juices dissolve more metal from utensils than do sweetened juices.
4. The corrosive effect of sweetened juices decreases as the concentration of sugar increases.
5. Acid juices dissolve more iron than chromium or nickel from stainless steel utensils in relationship to the amounts of these elements present in the stainless steel.
6. No measurable amounts of nickel were dissolved from any of the utensils.
7. The amounts of iron, chromium, and nickel dissolved are not believed to be great enough to be of concern from the health standpoint.

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Measuring Discoloration of Food Purees in Glass Tubes[a]

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(Manuscript received March 2, 1953)

A rapid and objective method to measure the relative darkness of pureed foods in test tubes has been investigated. Removal of the puree from the tube is not required, and results are available immediately. The correlation between results obtainable by this method and an ordinary reflectometric method was studied and found to be satisfactory.

In the course of an investigation of the nonenzymatic discoloration of certain processed fruits and vegetable products, the need was experienced for a simple apparatus capable of measuring objectively the darkening of samples of food purees in glass tubes incurred during storage. Since darkness readings were required at regular intervals during the storage period, it was necessary to measure through the glass wall of the test tubes. A photographic method designed for the same purpose was recently described by Eolkin.[c] Although this method provides an objective means of evaluating the discoloration of pureed foods, it requires elaborate and expensive equipment and involves time-consuming manipulations.

An alternate method, which has been in use in this laboratory for 2 years, employs a direct measurement with a photoelectric reflection meter. Since most instruments require the material to be placed upon or beneath a glass slide, it is usually necessary to remove a portion of the sample whose reflectance is to be determined.

[a] Contribution No. 884, Massachusetts Agricultural Experiment Station.

[b] Present address: Quaker Maid Company, Brooklyn, New York.

[c] Eolkin, Dave. Relative Color Evaluation of Food Purees Using Black and White Photography. *Food Technol.*, 6, 214-217 (1952).

Under these circumstances, the sample to be measured cannot ordinarily be kept for further observation without additional treatment to prevent spoilage. Furthermore, the removal of the puree from the container and its transfer into a cuvette or onto a slide represent a tedious operation in the examination of a large number of samples. Inasmuch as many of the experiments utilized standard size test tubes for the storage of the purees, it was found useful to adapt a Photovolt [4] reflectometer to the measurement of darkening of samples in the actual storage tubes.

APPARATUS

Several types of test tube holders, designed for use with the search unit of a Model 610 Photovolt Reflection Meter, were constructed and tested. The most satisfactory one, illustrated in Figure 1, was made from a wooden block 9 cm. x 9 cm. x 3.5 cm. To hold the sample tube, a horizontal hole 18 mm. in diameter was drilled, 0.5 mm. from the top surface. A vertical recess, 5 cm. in diameter, tangent to the tube track was made in the top to accommodate the head of the search unit. A series of metal disks, 4.8 cm. in diameter, were cut from 0.0015 in. (0.0037 cm.) steel plate. Apertures of different sizes, both circular and of the slit type, were cut in the center of the disks. Protruding lugs in the recess, corresponding to small holes drilled near the outer edge of the disks insured a fixed position for the disks when in use. The holder and the disks were sprayed with flat black paint to minimize any stray reflection of light.

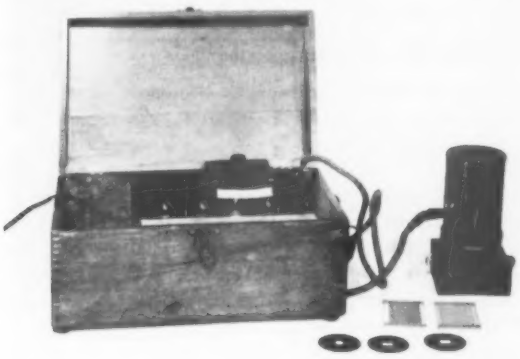

Figure 1. Photovolt Reflection Meter with search unit and test tube holder, showing a tube of puree in position for measurement. Lower right, bottom row: additional masks with round and slit type apertures. Upper row: Munsell paper standards.

The reflection meter is operated in the usual manner, i.e., the galvanometer is calibrated for maximum reflectance with a color standard. When only a comparison of relative darkness of one set of tubes was desired, tubes of the lightest purees were used as controls. For storage studies, Munsell paper standards were used for calibration. These standards could be fitted into a clean test tube and used in the holder, or could be used flat outside the holder. In the second method, covering the standard with a mask similar to the one in the holder had the advantageous effect of narrowing considerably the range of difference in darkness between standard and sample, thereby increasing the measuring range obtainable.

EXPERIMENTAL

A number of experiments designed to test the over-all usefulness and limits of applicability of the tube holder were carried out. The materials included powdered magnesium oxide, carbon black, and different food purees prepared in the laboratory and stored under varying conditions for different periods of time.

The white reflectance standard in the experiments was prepared by coating an aluminum slab with the smoke from a burning magnesium ribbon, in accordance with the official standard T 633 m-50 of the Technical Association of the Pulp and Paper Industry.

RESULTS AND DISCUSSION

Relationship between area size and reflectance of white surface. Inasmuch as any reduction in the size of the light spot from the search unit of the reflectometer decreases the amount of reflected light falling on the photocell, thereby diminishing the electrical current generated by it, there are definite limitations to the extent to which the instrument can be used to measure the reflectance of small areas.

The search unit of the Model 610 Photovolt Reflection Meter is designed to measure a circular area $\frac{5}{8}$ in. in diameter. Theoretical considerations would lead one to expect that any reduction in the size of the area of a uniform surface exposed to the light source would result in a directly proportional decrease in the quantity of light reflected. To check the validity of this premise, a series of 5 black masks with circular apertures of different diameters were made. With the instrument set to 100 for a white surface (Munsell N9; 80% Reflectance of MgO standard), the reflectance of the same standard with the masks was obtained. The resulting data, plotted against the area exposed, are presented in Figure 2. It may be seen that the calculated and observed values differ slightly even when a mask with an aperture of $\frac{1}{4}$ in. was used. Although each experimental value represents an average of 12 observations, it should be stressed that good reproducibility was obtained, the average deviation being $\pm$ 0.57% R.

Relationship between concentration of dark constituent and reflectance of mixtures in glass tubes. Inasmuch as the present technic is concerned with the measurement of darkening in various types of pureed foods, it was of primary interest to determine the limits of applicability of the method. To accomplish this, 4

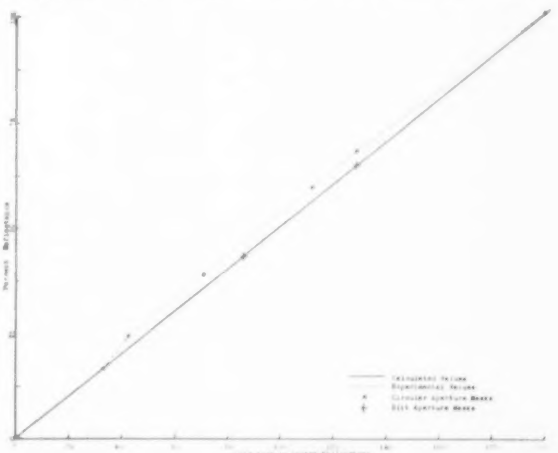

Figure 2. Relationship between area of white surface exposed to Reflection Unit and calculated and observed reflectance values.

[4] Manufactured by the Photovolt Corporation, 95 Madison Ave., New York 16, N. Y.

series of mixtures of different degrees of darkness were prepared by diluting a dark component with a lighter one, so that different concentrations of the dark constituent were obtained. The mixtures used were: (a) carbon black and powdered magnesium oxide, (b) storage-darkened applesauce and fresh frozen applesauce, (c) storage-darkened carrot puree and fresh frozen carrot puree, and (d) storage-darkened green bean puree and fresh frozen green bean puree. Results were plotted as illustrated in Figure 3. In each case, the darkness of the mixture increased very rapidly initially as increments of the dark constituents were added. A point was very rapidly reached, however, when a higher concentration of the dark component only slightly increased the over-all darkness of the mixture. This was most evident in the MgO-C mixture. Green bean puree showed a lesser, but more uniform loss in reflectance as the concentration of dark puree was increased. In all cases, this effect was quite apparent visually.

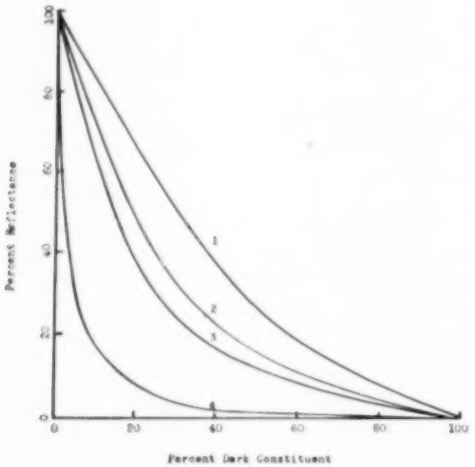

Figure 3. Reflectance of mixtures of : 1. Darkened and fresh green bean puree, 2. Darkened and fresh applesauce, 3. Darkened and fresh carrot puree, and 4. Magnesium oxide and carbon black.

Graded discoloration of pureed foods in glass tubes. Where oxidative darkening of food purees is involved, it is generally found that the most intense discoloration occurs near the upper surface of the puree. This type of discoloration, referred to as "ring browning" or "graded discoloration" can be measured very readily by the Photovolt Reflection Meter with the test tube holder, by using a ¼ in. slit aperture mask. Reflectance of ¼ in. bands along three year-old tubes of apple, bean and carrot purees were plotted against that distance from the surface of the food as illustrated in Figure 4. Greatest discoloration is noted in the pureed carrots, least for pureed apples. In all cases, an instrument reading of 100% R corresponded to Munsell standard 10 YR 8/6 with mask and 0% R to 5YR 3/4 with mask. No filter was used.

Relationship between tube method of reflectance measurement and conventional method. As previously indicated, the conventional use of a reflection meter for the measurement of puree color or darkness, involves its removal from the container, its transfer to a suitable cuvette and its measurement through a glass slide. In this manner, the full area of the search unit's aperture may be used, close contact between the unit and the sample is achieved, and a uniform and flat surface is obtained. To compare the reflectance values obtained by the standard method with those obtained on the same purees in test tubes, the reflectance of 10 concentrations of darkened applesauce was measured in both ways. Results presented in Figure 5 indicate a good correlation between the 2 methods.

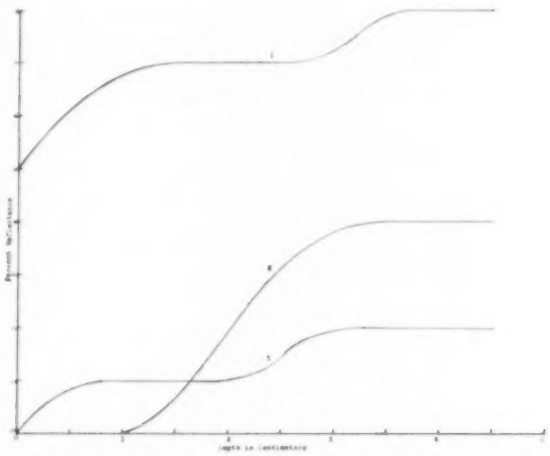

Figure 4. Reflectance of storage darkened purees of: 1. Green beans, 2. Carrots, and 3. Apples in glass tubes, at indicated distance from the surface of the puree.

Further data were obtained using 30 tubes of pureed carrots prepared and stored under various experimental conditions to show different levels of discoloration. In each case a top and bottom reading was obtained on the tube by a ¼ in. circular aperture mask. The contents of the tube were then carefully removed and reflectance readings obtained first on the uppermost portion and

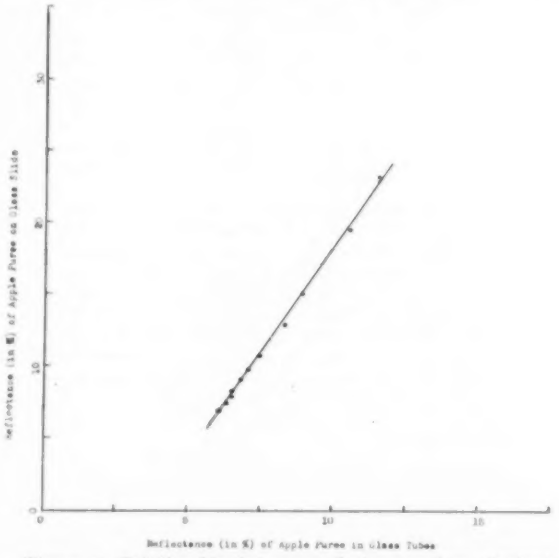

Figure 5. Relationship between reflectance values obtained for mixtures of darkened and fresh apple sauce by measurement in glass tubes and on glass slides.

next on the lowest portion of the puree. The values obtained were integrated into one discoloration value using the following formula:

$$D.I. = 10\,(E.R.D. + E.B.D.)$$

where

D.I. = Discoloration Index
E.R.D. = Effective Ring Discoloration
E.B.D. = Effective Body Discoloration

The Effective Ring Discoloration is the difference between the reflectance of the bottom and the top layers of the puree in a tube. The Effective Body Discoloration, which is the difference in reflectance between the bottom puree of the sample tube and the original puree at the start of a storage period, is a measure of the nonoxidative "body" or "diffused" discoloration which the puree has undergone.

The data on the carrot tubes were analyzed statistically, and a correlation coefficient of 0.9752 was obtained, indicating the close correlation between the two methods.

It should be noted that the usefulness of this method is by no means limited to the type of observation described herein. This technic is well suited to studies of discoloration or color changes in any type of comminuted food product. Given color changes can be followed by using the proper color filters in the search unit of the reflection meter.

SUMMARY

A photoelectric reflection meter, equipped with a special holder, for the measurement of darkening of food purees in glass tubes was evaluated. The method was found to be extremely rapid, simple, and as accurate as the conventional method requiring removal of the samples from their tubes. Judiciously selected color filters could adapt this technic to the measurement of changes in the color of purees.

Acknowledgments

The assistance of Dr. I. S. Fagerson in evaluating certain phases of this work is gratefully acknowledged.

The Use of Glucose Oxidase in the Processing of Foods With Special Emphasis on the Desugaring of Egg White[1]

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(Manuscript received September 3, 1952)

The Deoxygenase enzyme system first supplied by the Vita-Zyme Laboratories, and now manufactured by the Takamine Laboratory, has found commercial application in the food industry. This enzyme system contains glucose oxidase and catalase, and consequently in the presence of molecular oxygen brings about the oxidation of glucose to gluconic acid. The Deoxygenase enzyme system is applicable to food processing involving (a) the exhaustive removal of oxygen in the presence of an excess of glucose, and (b) the exhaustive removal of glucose in the presence of an excess of molecular oxygen. Results of experimentation and development work in applying Deoxygenase to the desugaring of commercial size batches of egg white are given in detail.

In 1948 an enzyme preparation known as Deoxygenase[2] was brought to our attention by the Vita-Zyme Laboratories, Inc. of Chicago, Illinois. The active components of this enzyme preparation were glucose oxidase and catalase. This system has been proposed for the removal of oxygen or the removal of glucose from food products.

HISTORY

In 1928 Muller *(15)* discovered an enzyme in *Aspergillus niger* and *Penicillium glaucum* which he called glucose oxidase. He showed that the enzyme brought about the oxidation of glucose by molecular oxygen to an acidic material which he found to be gluconic acid. Franke and Lorenz *(5)* prepared the enzyme in greater purity and found that hydrogen peroxide was formed when this enzyme was allowed to act on glucose. They also suggested that the enzyme was a flavo-protein. Coulthard *et al. (3)* prepared the enzyme from *Penicillium notatum* in much greater purity and named it notatin. Von Brugger *et al. (19)*, independently purified the enzyme and called it penicillin B. They suggested that the prosthetic group was alloxazine-adenine dinucleotide, and this was definitely proved by Keilin and Hartree *(11)*.

It is now generally conceded that glucose oxidase, notatin and penicillin B are one and the same enzyme which oxidizes glucose to gluconic acid and hydrogen peroxide in the presence of molecular oxygen and water. The enzyme is actually a glucose dehydrogenase, since it has been shown by Bentley and Neuberger *(2)* that the oxygen atoms of the produced hydrogen peroxide are derived from molecular oxygen and that the enzyme catalyzes the transfer of hydrogen from glucose to oxygen. The formation of hydrogen peroxide is supported by the fact that 4% to 7% peroxide has been found in reaction products formed in the absence of catalase *(4)*. The first product of the reaction is σ-gluconolactone which changes by nonenzymatic hydrolysis to gluconic acid. The bactericidal activity of the enzyme is due to the peroxide formation. Keilin and Hartree *(12)*, by noting the oxygen uptake, have used glucose oxidase to determine, quantitatively, glucose of biological materials. The glucose oxidase enzyme can be used for the removal of oxygen or the removal of glucose from solution since both are required in the reaction of producing gluconic acid.

Characteristics of the Deoxygenase enzyme system. The Deoxygenase enzyme system in terms of equations is given in Figure 1.

In accordance with these equations, the overall effect is the conversion of glucose to gluconic acid by molecular oxygen in the presence of the enzyme. The hydrogen peroxide formed is

[1] This paper was presented at the Institute of Food Technologists meeting at Grand Rapids, Mich., June, 1952.

[2] Deoxygenase is the trade name of the enzyme preparation originally supplied by the Vita-Zyme Laboratories, Inc., Chicago, Ill.; it is now manufactured by the Takamine Laboratory Inc., Clifton, N. J.

$$\text{Glucose} + O_2 \xrightarrow[\text{Oxidase}]{\text{Glucose}} \text{Gluconic Acid}$$

$$H_2O_2 \xrightarrow{\text{Catalase}} H_2O + \tfrac{1}{2}O_2$$

Figure 1. Equations defining the Deoxygenase enzyme system.

broken down in the presence of catalase in the Deoxygenase enzyme system to yield molecular oxygen, making it available for the oxidation of additional quantities of glucose. Keilin and Hartree *(9)* have studied the reaction in the presence of catalase. They showed that the oxygen uptake is equal to the theoretical amount required for the oxidation of glucose to gluconic acid, and have used this system as a method for glucose determination.

Glucose oxidase preparations, obtained from various sources, which have not been highly purified differ somewhat in their specificity in regard to the sugars which are oxidized and the rates at which the oxidation takes place. The enzyme isolated from plant material, *Phascolus radiatus* and *Phascolus mungo*, acted on galactose and mannose but not on fructose or xylose *(11)*. The enzyme from *A. niger* acted on mannose, xylose and galactose *(16)*. Glucose oxidase from a Penicillium preparation was reported to have the following reaction rates *(4)*: Glucose 1, galactose, 0.14, mannose 0.07. This relatively high galactose value was explained by the authors as probably due to impurities in the galactose. Crude enzyme preparations show some minor differences in specificity.

Keilin and Hartree *(10)* tabulate glucose oxidase reaction rates for a great variety of sugars using a purified preparation of glucose oxidase (80-90% pure).

The specificity of the Deoxygenase preparation, in regard to the types of sugars oxidized, was found to be as shown in Table 1.

The activities found using Deoxygenase with various sugars agree better with those reported by Franke and Deffner *(4)* for glucose oxidase obtained from *A. niger* than those reported for preparations from other sources.

The optimum pH reported in the literature for glucose oxidase activity varies from 4.2 to 7.8, depending upon the source of the enzyme preparation *(5, 14)*. An investigation of the optimum glucose oxidase activity of the Deoxygenase system of enzymes indicates an optimum in the range of pH 5 to pH 6. When using glucose or liquid egg white as a substrate, the changes in glucose oxidase activity of Deoxygenase with changes in pH are as indicated in Table 2. It is noted that there is an optimum pH with the buffered glucose substrate and with the egg white in the range of pH 5 to 6. However, the pH curve in the case of the pure glucose solution reaches a peak more abruptly. In these experiments the concentration of glucose in the pure sugar solutions was 0.125 molar whereas in the egg white it was only 0.0172 molar initially.

Keilin and Hartree *(10)* have discussed the kinetics of glucose oxidase catalase enzyme systems. Working with 80% to 90% pure glucose oxidase, they have shown that the temperature coefficient for the enzymatic oxidation of glucose to gluconic acid falls off rapidly with rising temperature. Oxygen uptake was determined by using 12.5 μg. glucose oxidase, 0.1 ml. catalase, 0.2 molar phosphate buffer pH 5.6 and determining oxygen uptake in μl. per 5-minute reaction period. Under these conditions, the temperature coefficient for the enzymatic oxidation of glucose to gluconic acid in air at 0° C. is 2, while at 30° C. (86° F.) the temperature coefficient is 1.06. Since oxygen is a reactant in the conversion of glucose to gluconic acid, it is apparent that the availability of oxygen in the solution is an important factor in determining the reaction rate. At 39° C. (102.2° F.) the reaction rate is nearly 2½ times higher when run in oxygen rather than air under the same experimental conditions *(10)*. The addition of hydrogen peroxide to the reaction mixture is a convenient method of supplying oxygen for the enzymatic oxidation of glucose to gluconic acid. The effect on rate of reaction of the enzymatic oxidation of glucose in egg white in the presence and in the absence of hydrogen peroxide is shown in Figure 2.

TABLE 1

Deoxygenase reaction rates

Sugar	Initial Sugar Concentration	pH[b]	Activity (O_2 Uptake, μl./hr.)[c]	Relative Activity
Glucose	0.125 M	5	3600.0	100.00
Maltose	0.125 M	5	13.2	0.37
Maltose	0.250 M	5	35.3	0.98
Galactose	0.125 M	5	22.0	0.61
Mannose	0.125 M	5	0.7	0.02
Glucosamine	0.125 M	3.9	0	0
Xylose	0.125 M	5	0	0

[b] The reactions were run in phosphate-citrate buffer, except those at pH 8 and pH 9, which were run in glycine-sodium hydroxide buffer.

[c] Activities were determined in an atmosphere of oxygen by standard Warburg techniques and expressed as microliters (µl.) of oxygen absorbed per hour under the conditions of the test.

The reaction rate was determined for a 5-minute period starting about 15 minutes after the enzyme addition, and calculated as µl. per hour. In the case of mannose, the rate was determined for a 45-minute period starting about 15 minutes after the enzyme addition.

Conditions of reaction: 38° C., 0.5 ml. sugar solution, 0.5 ml. Deoxygenase, 1.0 ml. buffer; 120 oscillations per minute in standard Warburg apparatus.

TABLE 2

Effect of pH on the activity of Deoxygenase in egg white and pure glucose

	Buffered[a] pH	Activity (O_2 Uptake, µl./hr.)[b]
Commercial Frozen Egg White Containing Natural Glucose (Swift & Company)	3	220
	4	515
	5	478
	6	517
	7	503
	9	240
0.125 Molar Glucose Solution (Initial Concentration)	3	2004
	4	2484
	5	3600
	6	2736
	7	2040
	8	1176
	9	988

[a] Phosphate-citrate buffer was used, except for determinations at pH 8 and pH 9 in which glycine-NaOH buffer was used.

[b] The activities were determined in an atmosphere of oxygen for a 5 minute reaction period starting about 15 minutes after the enzyme addition, and expressed as microliters of O_2 absorbed per hour under the conditions of the test.

Conditions—38° C., 0.5 ml. glucose (0.5 M solution), or 0.5 ml. egg white, 1.0 ml. buffer and 0.5 ml. Deoxygenase. Shaken at 120 oscillations per minute in standard Warburg apparatus.

In dilute glucose solution, the oxidation of glucose to gluconic acid in the presence of Deoxygenase is a first order reaction with respect to glucose. In Figure 3 is plotted the initial reaction rates against the initial glucose concentration. These initial reaction rates were determined by plotting the logarithms of the rate of oxygen uptake at 5-minute intervals and extrapolating to zero time. The fact that the points in Figure 3 fall on a straight line indicates the rate of reaction is proportional to the glucose concentration. As in glucose solutions the rate of ezymatic removal of glucose in egg white is proportional to the glucose concentration. In Figure 4 is plotted the logarithm of the glucose concentration against time of reaction. The fact that this curve is a straight line indicates that this desugaring reaction is first order in respect to glucose.

It also appears that the enzymatic oxidation of glucose to gluconic acid in the presence of Deoxygenase is a first order reaction with respect to the enzyme. In dilute enzyme solutions (up to 0.005% deoxygenase, dry basis), the rate of oxidation is directly proportional to enzyme concentration.

Deoxygenase assay. The Vita-Zyme Laboratories have defined a unit of Deoxygenase activity as that amount of enzyme which will take up oxygen at a rate of 10 μl. per minute under their conditions of assay.

In our investigation we have evaluated Deoxygenase preparations in respect to the glucose oxidase activity as determined by oxygen consumption under somewhat different conditions. In this assay the oxidase activity is determined at pH 5.8 in an atmosphere of oxygen with constant shaking on the Warburg apparatus. Since the Deoxygenase system of enzymes contains sufficient catalase to break down any hydrogen peroxide formed in the glucose oxidation reaction, the amount of oxygen consumed is related to the amount of sugar oxidized.

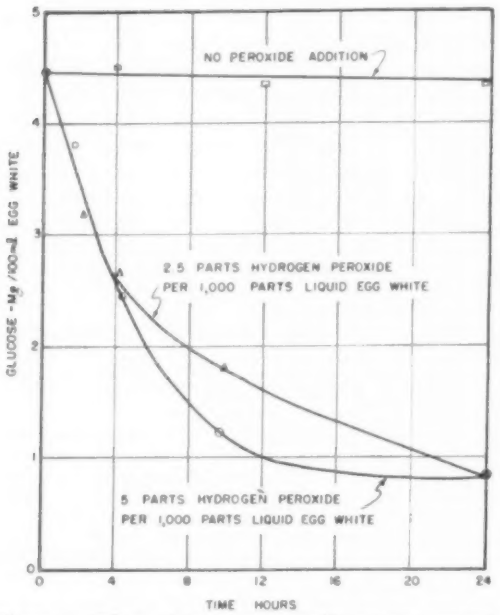
NO PEROXIDE ADDITION
2.5 PARTS HYDROGEN PEROXIDE
PER 1,000 PARTS LIQUID EGG WHITE
5 PARTS HYDROGEN PEROXIDE
PER 1,000 PARTS LIQUID EGG WHITE
GLUCOSE - Mg./100 ml. EGG WHITE
TIME HOURS

Figure 2. Effect of hydrogen peroxide on the removal of glucose from liquid egg white. Enzyme 1 to 1000; temp. 4° C.; catalase present.

The assay procedure for determining the activity of the Deoxygenase is as follows:

Prepare a 3% glucose solution in McIlvain's pH 5.8 buffer. McIlvain's pH 5.8 buffer is prepared by dissolving 21.4902 gm. $Na_2HPO_4.12\ H_2O$ and 4.202 g. anhydrous citric acid in distilled water and diluting to 500 ml. The 3% glucose solution is prepared from 15 g. of CP anhydrous glucose and made up to 500 ml. with the buffer. This glucose solution is cooled in an ice bath and 0.5 ml. of the Deoxygenase added. Shake by hand for 2 minutes, then add 2.0 ml. of the enzyme-glucose-buffer solution to the Warburg cups. Attach cups to manometers and sweep with oxygen for 5 minutes. Place flask in the Warburg bath at 38° C. and shake at 120 oscillations per minute. The flasks are equilibrated for 10 minutes with stopcock open. The thermobarometer contains 2 ml. of distilled water. The reaction involving the oxidation of glucose in the presence of glucose oxidase, resulting in the absorption of oxygen, is allowed to progress for a period of 60 minutes. After this reaction period, readings are taken and the correction made for the changes in the thermobarometer. The activity of the enzyme in terms of the Deoxygenase unit is given by the following equations:

$$\text{Deoxygenase Activity}\ \frac{\text{units}}{\text{ml.}} = \frac{\text{Oxygen taken up } (\mu\text{l.})}{10 \times \text{time (min.)} \times \text{vol. enzyme (ml.)}}$$

$$\frac{\text{oxygen taken up } (\mu\text{l.})}{1.2}$$

In this paper the Deoxygenase activities are given in the unit as defined by the Vita-Zyme Laboratories (1 unit = 10 μl. oxygen taken up per minute), but the determination was made in accordance to the assay outlined above.

The conditions of assay outlined are somewhat different from those independently developed by the Vita-Zyme Laboratories in their assay procedure. Due to the difference in conditions employed, the rate of oxygen absorption is somewhat different in the 2 assay procedures. It has been found that enzyme standardized by the Vita-Zyme Laboratories at 200 units per ml. will assay about 175 units by the assay procedure described above. The assay described above is convenient to manipulate and gives reproducible results. For these reasons this assay was preferred for the determination of enzyme activity in our investigations.

The Takamine Laboratory has developed an assay procedure based on the titration of the acid formed by the oxidation of glucose under standardized conditions *(13)*.

Application of glucose oxidase to food processing. Due to the limited availability of glucose oxidase for commercial or even explorative investigation, its application to food processing has until recent years been limited to investigative work. The Deoxygenase system contains catalase as well as glucose oxidase. The presence of catalase avoids the accumulation of hydrogen peroxide formed in the oxidation reaction of sugar to gluconic acid, and consequently in the presence of an excess of glucose permits the enzyme system to exhaust the media of dissolved oxygen and hydrogen peroxide. One of the early samples of

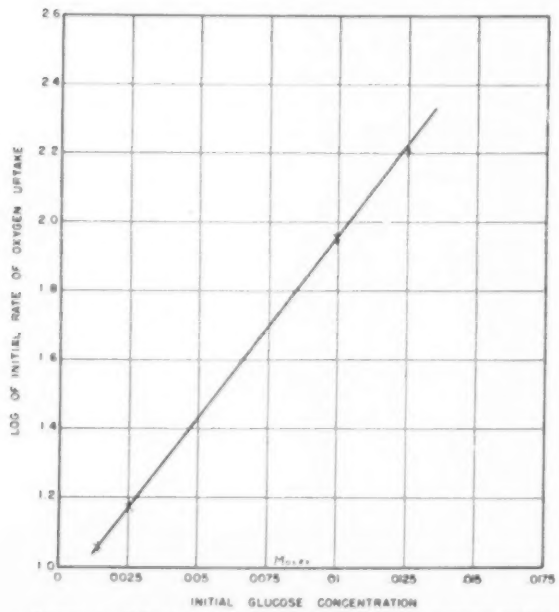

Figure 3. Effect of glucose concentration on oxygen uptake by Deoxygenase. Temp. 38° C.; pH 5.0; catalase present.

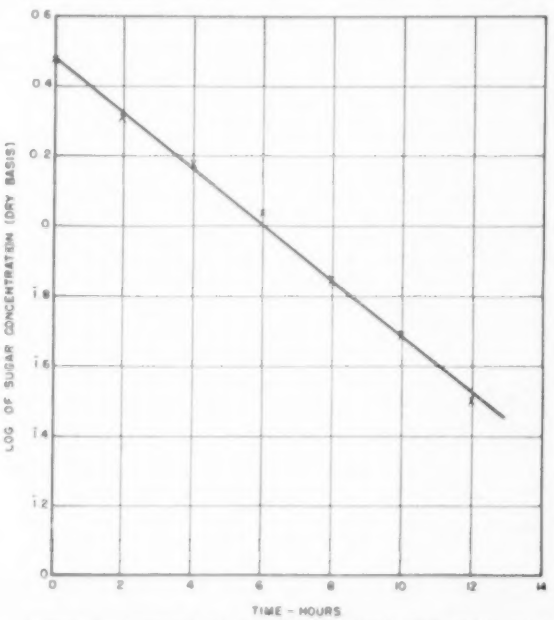

Figure 4. Removal of sugar from liquid egg white with Deoxygenase. Deoxygenase 1 lb./2000 lbs. liquid egg white; temp. 80° F.; H_2O_2 (130 vol.) 9 lbs./2000 lbs. liquid egg white; pH 7.4.

Deoxygenase investigated in our laboratory was found to show a catalase activity sufficient to decompose 25 mg. of hydrogen peroxide. The catalase activity was determined at a temperature of 25° C. at pH 7, in accordance with the procedure recommended by the Vita-Zyme Laboratories for the standardization of their enzyme, Catalase Sarett.

Determination of Catalase Activity. A quantity of catalase, depending upon activity is pipetted into a 250 cc. beaker. At zero time 100 ml. of 1.5% hydrogen peroxide, pH 7 (phosphate) 25° C. is poured in upon the catalase and the contents mixed. The beaker is covered and allowed to stand until the reaction is complete (one-half hour in case of Catalase Sarett, about one hour for Deoxygenase). Four ml. of this solution is pipetted into a small Erlenmeyer flask or an 8" x 1" test tube and 5 ml. of 2 N sulphuric acid added, followed by approximately 2 g. of potassium iodide. The liberated iodine is titrated with 0.25 N thiosulphate. A similar titer is carried out, using 4 ml. of the stock 1.5% hydrogen peroxide solution.

The sample of Deoxygenase used in these experiments showed a glucose oxidase activity of 180 units per ml. In any enzymatic desugaring process, the oxygen is supplied in excess in order to drive to completion the glucose oxidation reaction. Although atmospheric oxygen can be used, it has been found advantageous, in certain processes, to supply oxygen to the system by means of hydrogen peroxide. The catalase in the Deoxygenase enzyme system liberates from the hydrogen peroxide the molecular oxygen required for the oxidation reaction.

The enzyme system is applicable to (a) food processes or products in which small amounts of oxygen bring about product deterioration during processing or storage, and (b) those products and processes in which small amounts of glucose are responsible for deterioration of product quality during processing or storage.

The processing of beer by the use of Deoxygenase will serve as an example in the field of food processing involving the removal of oxygen. The process has been investigated by the Vita-Zyme Laboratories and has been demonstrated to be effective on commercial scale tests. It is probable that the type of deoxygenation may have application in the processing of natural fruit juices, where small amounts of oxygen have been reported to be responsible for the development of off-flavors during pasteurization and storage. The application of Deoxygenase to the processing of orange juice has been reported previously by Kaufman and Campbell *(8)*. It was found in this investigation that orange juice treated with small amounts of Deoxygenase developed a typical stale aroma and flavor much more rapidly than the controls containing no enzyme. Under the chosen set of conditions in the work with orange juice, reactions in addition to oxygen removal obviously took place.

The processing of egg white by the use of Deoxygenase is an excellent example of food processing involving the removal of glucose. Dried egg white containing natural sugar rapidly deteriorates upon storage *(18)*. The conventional egg white process involves the removal of sugar by bacterial or yeast fermentation. These processes based on fermentation are rather difficult to control, since, besides the desired removal of sugar, proteolytic and other undesired reactions take place. The product is consequently subjected to the development of off-flavors due to the method of sugar removal. The application of glucose oxidase represents a marked improvement in the desugaring of egg white. The desugaring process, involving the use of Deoxygenase, has more recently been applied to dried whole eggs. Dried eggs produced by this enzyme desugaring process show promise of markedly good storage characteristics. Enzyme desugaring may find application in other fields of the food processing industry where small amounts of glucose limit the quality of the product produced.

COMMERCIAL APPLICATION OF DEOXYGENASE TO THE MANUFACTURE OF DRIED EGG WHITE

To date the most extensive commercial application of glucose oxidase for the processing of foods has been in the field of the manufacture of dried egg white.

As mentioned above, the conventional methods of bacterial and yeast fermentation are subjected to control problems, and at times result in *off* and objectionable flavors and odors in the finished product. This limits their use in the food industry, although Hawthorne *(6)* and Kaplan *et al. (7)* have indicated that improved yeast and bacterial procedures are possible. It has been found that the use of enzyme desugaring consistently results in a dried agg albumen product of uniform quality, free from *off* or objectionable odors traceable to the desugaring process. Besides the distinct flavor advantage in the finished product, the enzyme desugaring process offers several other advantages:

(a) By the use of standardized enzyme, the processing time involved in the desugaring operation is easily controlled.

(b) The acid produced during the desugaring operation comes only from the sugar oxidized. Enzyme desugaring consequently results in a uniform product at the time of drying. In the conventional bacterial fermentation process, variable amounts of acid are formed, dependent upon the fermentation culture and conditions. This formation of acid usually results in the separation of the mucin fraction and requires skimming and separate processing procedures for the mucin fraction. By the proper selection of processing conditions for the enzyme desugaring process, the separation of mucin is avoided. Thus, the process is simplified and gives a uniform product.

(c) The classical bacterial and yeast fermentations result in the formation of carbon dioxide and volatile acids, which are lost in the drying process and consequently decrease the yield of dried egg albumen produced. In the enzyme desugaring process, the protein and non-sugar materials are not attacked by the enzyme; consequently, no weight loss is realized. The small amount of gluconic acid formed by the oxidation of glucose is non-volatile, and thus remains in the finished dried egg albumen. See Table 3.

(d) Inasmuch as the enzyme desugaring process for the manufacture of egg albumen does not involve the growth of microorganisms, the many sanitary problems involved in the bacterial and yeast desugaring of egg white are avoided. The time involved in the enzyme desugaring of egg white is dependent upon the level of enzyme used. Pilot plant and initial commercial desugaring by the use of enzyme has indicated that enzyme levels, campatible with good economic processing, involve processing times much shorter than the conventional bacterial and yeast fermentation.

The older conventional bacterial and yeast fermentations are dependent upon microorganism growth, and consequently must be conducted under conditions favorable to rapid increase of microorganisms present. The enzyme desugaring process is conducted under conditions unfavorable to microorganism increase and growth. The process of oxidation of glucose by atmospheric oxygen in the presence of the Deoxygenase enzyme system results in the formation of hydrogen peroxide. Besides the hydrogen peroxide formed in the sugar oxidation reaction, it is conventional to supply

TABLE 3

Change in solids of liquid albumen before and after sugar removal by Deoxygenase

Run No.[1]	Original Solids	Final Solids	Change
	%	%	
1 and 2	11.98	12.04	+0.06
3	11.97	11.99	+0.02
4 and 5	12.16	12.22	+0.06
6 and 7	11.95	11.94	−0.01
8 and 9	11.94	11.93	−0.01
11	11.95	11.95	0.00
12 and 13	12.26	12.26	0.00
14 and 15	12.04	12.04	0.00
Average			+0.015

[1] See Table 4 for condition under which these commercial size runs were made.

the oxygen required for this reaction by the addition of hydrogen peroxide to the egg whites to be desugared. Depending upon the amount of hydrogen peroxide present from these 2 sources, the microorganisms are inhibited in growth, and at high levels of hydrogen peroxide are actually decreased in number. See Table 4. The importance of sanitation during egg white processing gives the enzyme process a distinct advantage, since the growth of undesired types of microorganisms, such as Salmonella in the conventional fermentation processes, at times results in health hazards.

The desugaring of egg white by the use of Deoxygenase has been carried out on commercial size batches in cooperation with the Henningsen Company in their plant at Lamesa, Texas. The equipment employed in this test is diagrammatically indicated in Figure 5. Pertinent details for this commercial desugaring process follow:

Size of batch (freshly separated egg white or defrosted frozen egg white)—4000 lbs. liquid egg white
Temperature during processing—79° to 80° F. (26.1° to 26.6° C.)
Acid used for pH adjustment—5% hydrochloric acid
pH adjustments prior to enzyme addition—pH 7.3
Enzyme level (assay 174 units per ml.)—1 lb. Deoxygenase per 2000 lbs. liquid egg white
Hydrogen peroxide level (130 volume, DuPont)—4.6 lbs. per 1000 lbs. liquid egg white
Processing time (time required to reduce sugar level to about 0.1% glucose, dry wt. basis)—Approximately 15 hours
Final pH (before drying)—pH 6.4
Drying—The egg white was dried without further treatment using both spray drying and tray drying techniques.

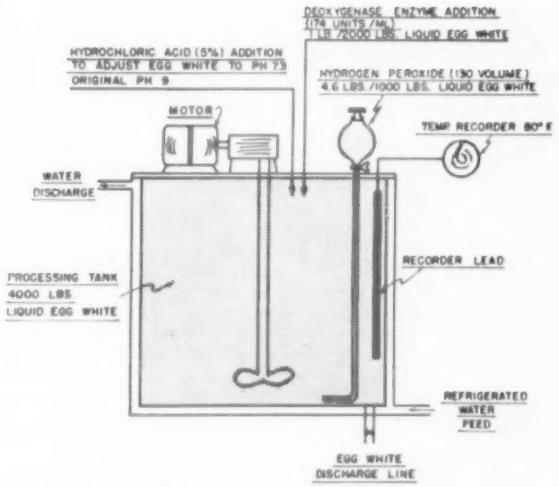

Figure 5. General plan for commercial batch operation. Processing time approx. 15 hrs.; initial glucose conc. 3.4% (dry oasis); final glucose conc. less than 0.1% (dry basis).

The adjustment of the egg white is preferably carried out by the addition of rather dilute acids during rapid agitation, in order to avoid local high concentration of acids and the associated changes in the liquid egg white. In this work, it was found that a pH in the range of 7.4 was most advantageous after considering the effect of pH on the reaction rate of the enzyme, as well as the effect of the acid on the egg white being treated. During the desugaring operation the pH of the batch dropped about one pH unit, due to the formation of gluconic

Table 4
SUMMARY DATA SHEET OF EGG WHITE PROCESSING

															RUN NUMBER	
*	Fresh Frozen	*	Frozen	*	*	*	*	*	*	*	*	*	*	Frozen Fresh	Type of Egg	
4000 5.0 9.0 12.04		4000 3.1 8.8 12.28		4000 3.4 9.0 11.95 -		4000 3.1 9.2 11.94		4000 3.1 9.0 11.95		4000 3.4 9.0 12.16		4000 5.0 9.0 11.97	4000 3.0 9.0 11.98		Size of Batch in lbs. % Glucose pH % Solids	Raw Material Liquid Egg White
Good 6.13	Good 6.13	Good 6.25	Good 6.25	Good 6.50	Good 6.50	V. Good 7.25	V. Good 7.25	V. Good 6.25	V. Good 6.25	V. Good 6.0	V. Good 6.0	Good 6.50	Good 6.25	Good 6.25	Body Whip Whip-Height (Inches)	
2,420,000* 244,000 0 0		123,000 13,000 0 0		536,000 103,000 0 0		9,100* 91,000 0 20		810,000 56,000 80 10		475,000 3,000 10 20		462,000 139,000 0 0	253,000 58,000 0 0		Standard Count (per ml.) Coliform (per ml.) Yeast (per ml.) Mold (per ml.)	
79-80 7.4 5.5% HCl 1/500		79-80 7.3 5.2% HCl 1/2,000		79-80 7.4 5.5% HCl 1/2000		103 7.3 5.5% HCl 1/1000		79-80 7.35 5.5% HCl 1/2000		79-80 7.4 42.5% L.A. 1/1000		79-81 - - 1/2000	79-83 7.35 5.5% HCl 1/2000		Temp. of Adjusted pH Acid used Enzyme Conc. $\frac{\text{(lbs. enzyme)}}{\text{(lbs. egg white)}}$ (174 units per ml.)	Enzyme Deoxygenase
5.3/1000 6 hrs. 0.01 0.01 6.3 6.3 12.06		4.6/1000 15 hrs. 0.10 0.12 6.4 6.4 12.28		4.6/1000 15 hrs. 0.22 0.12 6.4 11.96 -		4.6/1000 6 hrs. 0.1 6.6 11.98		4/1000 10 hrs. 6 hrs. 0.58 1.0 6.3 6.4 11.94		5.6/1000 10 hrs. 0.05 6.5 12.22		13/1000 32 hrs. 0.02 6.65 11.99	5.9/1000 15 hrs. 0.14 6.4 12.04		H_2O_2 (130 Vol.) $\frac{\text{Conc. (lbs. } H_2O_2\text{)}}{\text{(lbs. egg white)}}$ Length of Run Final % Glucose Final pH % Solids	
V. Good 6.75	V. Good 6.75	Good 7.0	Good 7.0	V. Good 7.22	V. Good 7.25	Good 6.8	Good 6.5	-	-	V. Good 6.22	V. Good 6.25	- -	Good 7.0	Good 7.0	Body Whip Whip-Height (Inches)	
490,000 269,000 0 0		68,000 63,000 0 0		94,000 68,000 0 10		98,800 54,000 5 5		98,800 36,000 5 15		180,000 67,000 15 0		118,000 55,000 0 0	1,105,000 309,000 0 0		Standard Count (per ml.) Coliform (per ml.) Yeast (per ml.) Mold (per ml.)	
1925 4.60 6.0 4.1% HCl - nutrin removed	1925 6.0	2000 5.9 7.6% HCl -	1925 6.4 -	2000 6.4 - 6% nutrin removed	1925 6.0 4.0% HCl	2000 6.2 42.5% L.A. -	1925 6.6 -	2000 5.0 - 6.2% HCl -	1925 6.0 -	2000 5.6 42.5% L.A. -	1925 6.5 -	1925 6.85 -	1925 5.5 6.2% HCl -	1925 6.4 -	Size of Batch in lbs. Final pH Acid used Other Additions	Processing Adjustments
Spray 1925 295 16.	Spray 1925 290 183	Spray 2000 290 185	Spray 1925 288 185	Spray 2000 250-273 175-183	Spray 1925 250-240 170-180	Spray 2000 292 184	Spray 1925 292 183	Spray 2000 294 183	Spray 1925 296 184	Spray 2000 296 184	Spray 1925 290 185	Spray 1925 290 188	Spray 1925 300 184	Spray 1925 296 184	Type of Dryer Size of Batch in lbs. Inlet Air °F. Outlet Air °F.	Spray Drying Process
4.8 Good No Body 2-1/4	6.95 Good V. Soft 2-3/4	6.7 Good No Body 2-1/4	8.6 Good V. Soft 2-1/4	8.5 Off V. Soft 3-1/4	5.2 Good Soft 3-1/4	5.45 Good No Body 2-1/4	6.9 Good No Body 2-1/2	5.05 Good No Body 2-1/2	5.1 Good No Body 2-1/4	6.1 Good No Body 2-1/2	6.6 Good No Body 2-1/2	9.2 Good No Body 1-3/4	5.9 Good V. Soft 3-1/4	8.5 Good V. Soft 2-1/2	Recount, 1M Odor Body Whip Whip-Height (Inches)	Spray Drying Product
Pan 75 84 126	Pan 75 88 126	Pan - - 126	Pan 75 88 126	Pan - 81 126	Pan 75 - 126	Pan - 75 90	Pan - - 126	Pan - 75 126	Pan - 84 126	Pan - 75 126	Pan - 90 126	Pan 75 82 126	Pan 75 84 126	Pan 75 84 126	Type of Dryer Size of Batch in lbs. Air Temp. °F. Water Temp. °F.	Pan Drying Process
6.4 Good Soft 5	7.0 Good Fair 6	- - - -	8.1 Good Fair 3-3/4	- - - -	5.0 Good Soft 5	- - - -	8.4 Good Soft 5	- - - -	8.4 Off No Body 2	- - - -	8.2 Good V. Good 4-3/4	8.9 Poor No Body 2-1/2	8.0 Poor No Body 2-3/4	8.7 Poor Fair 3-7/8	Recount, 1M Odor Body Whip Whip Height (Inches)	Pan Drying Product

* Since the eggs used in these runs came from a uniform batch, these values are obviously in error.

acid from the oxidation of glucose. After adjusting the pH of the egg white the enzyme was then added, and finally the hydrogen peroxide was added, with gentle agitation to insure adequate distribution, as follows:

The hydrogen peroxide was first added to the tank at a rapid rate in order to bring the egg whites quickly up to saturation in respect to oxygen. This required the addition of about one-half pound of hydrogen peroxide per 1000 pounds of liquid egg white. This addition took place over a period of 5 to 10 minutes. After this initial rapid addition, hydrogen peroxide was continually and uniformly added to the tank at such a rate as to compensate for loss of oxygen, as well as supply the necessary oxygen for the desugaring reaction. The rate at which the hydrogen peroxide was added was so adjusted that the total amount added to the tank was in the range of 4 to 6 pounds of hydrogen peroxide to 1000 pounds of liquid egg white. In tests reported above, the hydrogen peroxide was used in an excess of the quantity required for the desugaring reaction. Since it was used in excess, the exact quantity used had only a minor effect on the rate or nature of the desugaring reaction.

The desugaring process may be continued as long as required in order to achieve the degree of sugar removal desired. When operating within reasonable ranges, there is no evidence of damage due to over treatment by the enzyme. It is necessary for the operator to insure himself of the desired sugar removal prior to drying. The egg producers use several empirical heating tests to indicate qualitatively the absence of sugar. These tests have value in empirically controlling the desugaring process. The final sugar content noted above as 0.1% is given on the basis of dry albumen, rather than on a liquid egg white basis. We have found it advantageous in our work to state all sugar determinations on the basis of dry albumen. Considerable difficulty was encountered in the development of a reproducible glucose analysis of enzyme desugared egg white. The method described below is based on the clarification procedure used by Stewart and Kline *(18)* and the glucose determination of Somogyi *(17)*.

Analytical method for Glucose[a]

Reagents:

Phosphotungstic Acid, C.P.
Potassium Chloride: saturated solution
Somogyi Copper Reagent
28 g. anhydrous disodium phosphate
100 ml. 1 N NaOH (4 g./100)
40 g. Rochelle Salts
8 g. $CuSO_4 \cdot 5H_2O$
180 g. anhydrous Na_2SO_4
} to 1 liter

Preparation: Dissolve phosphate and tartrate in about 700 ml. water. Add NaOH, then with stirring 80 ml. of a 10% copper sulphate solution. Finally add sodium sulphate and when this is dissolved, dilute to one liter. Let stand a day or two. Then filter through a good grade of filter paper.

Add 15 ml. 1 N KIO_3 per liter (for egg white concentration up to 3.0% dextrose [dry basis]).
Potassium Iodide: 25% (25 g. per 100 ml. + knife tip of Na_2CO_3).
Sulfuric Acid: 2N
Sodium Thiosulfate: 0.005N (Prepare by diluting 50 ml. of 0.100 N to 1 liter.) Add about 2 ml. of 10% NaOH per liter.
Soluble starch: 1%.
Standard Dextrose: 0.05%.

Clarification: Pipette 8 ml. of liquid egg white to a 100 ml. volumetric flask. Add about 50 ml. of water and 1 gm. of phosphotungstic acid. Shake well. Let stand at least ten minutes (at this point the sample may be stored in refrigerator until it is convenient to complete the determination). Add 15 ml. of staturated potassium chloride solution, mix well and make to mark. One drop of octyl alcohol may be used to break the foam if necessary. Filter through No. 40 Whatman paper discarding the first few ml.

Glucose determination: Pipette 5 ml. of the copper reagent and 5 ml. of the clarified extract into a 20 x 200 mm. pyrex test tube. Mix. Place in a vigorously boiling water bath for ten minutes.

Remove from bath, cool in running water. Add 2 ml. of the potassium iodide solution, running the KI down the side of the tube without stirring.

Then add rapidly and with agitation about 1.5 ml. of approximately 2 N sulfuric acid. Shake well until all precipitate is dissolved and the solution is clear.

Titrate with the 0.005 N thiosulfate using a 25 ml. burette. Add about 5 drops of 1% soluble starch toward the end of the titration and titrate to the disappearance of the blue color.

Set up blanks using 5 ml. of H_2O instead of the sugar solution with each series of determinations. Standards containing 0.5, 1.0 and 1.5 mg. dextrose should be run each time the Somogyi reagent or the thiosulfate is changed. Each ml. of 0.005 N thiosulfate is equivalent to approximately 0.134 mg. dextrose.

The factors found in the explorative and laboratory experimentation indicated that enzyme level, pH, temperature and availability of oxygen were the major factors in controlling the process of desugaring liquid egg white. Consequently, these factors were further investigated in our initial plant runs on a commercial scale. The many technical data pertinent to these plant runs are tabulated in Table 4. A study of these data brings out many valuable correlations, a few of which can be discussed in some detail.

Under conditions for commercially desugaring egg white, the rate of sugar removal was found to be roughly proportional to the enzyme level used. This relationship is diagrammatically indicated in Figure 6. The rate of sugar removal is plotted for batches treated with Deoxygenase enzyme at the levels of 1 to 500, 1 to 1,000, 1 to 2,000, on a weight basis.

In commercial application, the preferred level of Deoxygenase enzyme is dependent upon economic as

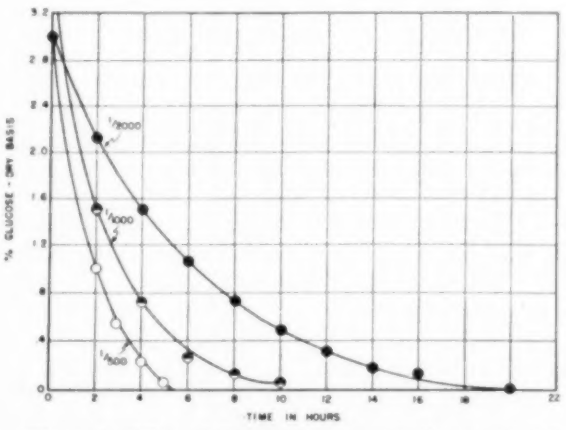

Figure 6. Effect of Deoxygenase concentration on rate of sugar removal from egg white. Temp. 80° F.; H_2O_2 (130 vol.) 2.4 lbs. - 4.5 lbs. per 1000 lbs. liquid egg white; pH 7.4; Deoxygenase assay 174 units per cc.

[a] The authors are indebted to N. H. Ishler and K. Shoman (Central Laboratories, General Foods Corp.), under whose direction this very satisfactory glucose method was developed.

well as other processing and product quality variables. It is apparent that the relative importance of these factors will vary from time to time, and from producer to producer. For this reason no generalization can be drawn in regard to the preferred level of enzyme concentration for any particular producer.

As was found in laboratory experimentation, the pH of the egg white processed has a marked effect on the rate of glucose removal by the enzyme, Deoxygenase. Figure 7 indicates the marked difference in rates of reaction of 2 commercial size batches. In one batch the enzymatic desugaring process was carried out without pH adjustment, and thus started at pH 9; in the other batch the desugaring process was carried out after adjusting the pH to 7.4 prior to enzyme addition.

In order to take advantage of the high rate of desugaring at pH values closer to the optimum for Deoxygenase activity, it was found advantageous to adjust the pH of the egg white to about 7.4 prior to enzyme addition. During the desugaring operation, the pH drops to about 6.4 as indicated in Table 4. By processing in this pH range it was possible to take advantage of the high rates of Deoxygenase activity and still not drop to a pH sufficiently low to cause the separation of mucin during the desugaring operation involving the formation of gluconic acid. The fact that this enzymatic desugaring operation can be carried out without the separation of mucin results in certain processing advantages not always enjoyed by the conventional bacterial and yeast fermentations which often require the separation and special handling of mucin.

Only 2 temperatures were investigated in the plant scale runs on the enzymatic desugaring of egg white. The rate of desugaring at 80° F. (26.6° C.) and at 103° F. (39.6° C.) is indicated in Figure 8. It is noted that the time required to desugar down to the level of 0.1% of glucose in the finished dried product, under conditions of test, is 9 hours at 80° F. and 7 hours at 103° F. Since pH and availability of oxygen have a much greater influence on the rate of desugaring than temperature changes in the range, it is probable that processing considerations, other than rate of sugar removal, will determine the preferred temperature for enzyme desugaring in a particular plant. A consideration of possible albumen changes and microorganism growth would suggest that temperatures of 80° F. and below would be preferred for enzymatic desugaring in so far as they are compatible with existing plant practice and processing ease.

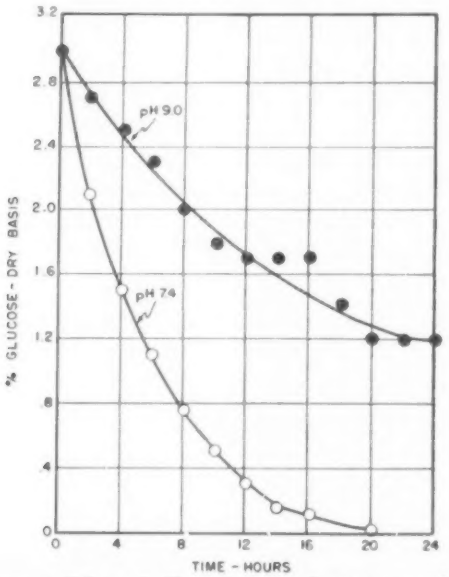

Figure 7. Effect of pH on the rate of sugar removal from fresh egg white by Deoxygenase. Deoxygenase 1 lb. per 2000 lbs. liquid egg white (assay 174 units per cc.); temp. 80° F. (26.2° C.); H_2O_2 (130 vol.) 4.6 lbs. per 1000 lbs. liquid egg white.

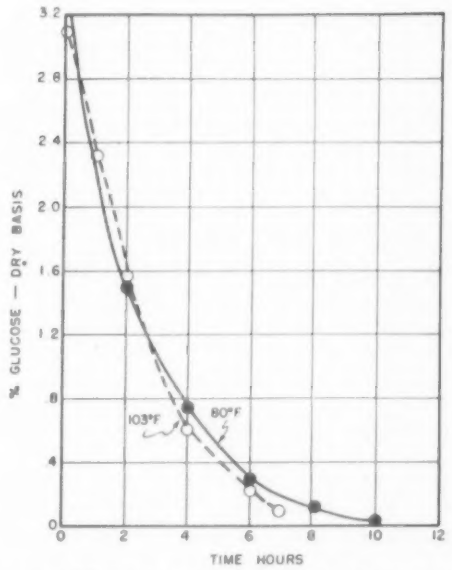

Figure 8. Effect of temperature on rate of sugar removal by Deoxygenase from fresh egg white. Deoxygenase 1 lb. per 1000 lbs. liquid egg white (assay 174 units per cc.); H_2O_2 (130 vol.) 4.6-5.6 lbs. per 1000 lbs. liquid egg white; pH 7.3-7.4.

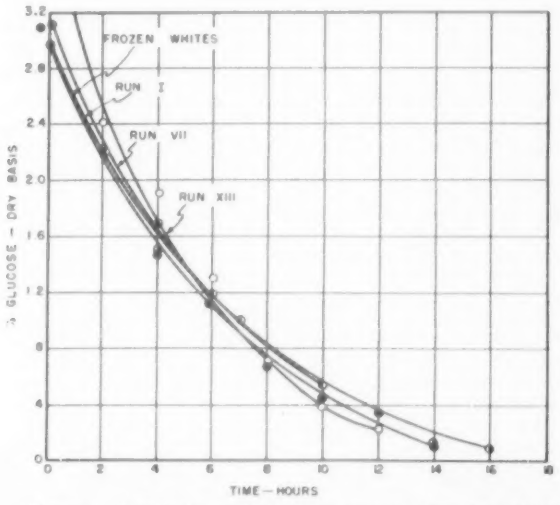

Figure 9. Replicate runs of sugar removal from egg white by Deoxygenase. Deoxygenase, 1 lb. per 2000 lbs. liquid egg white (assay 174 units per cc.); H_2O_2 (130 vol.) 2.9-4.5 lbs. per 1000 lbs. liquid egg white; pH 7.3-7.4.

Laboratory experiments and early development work indicated the importance of availability of oxygen [b] on the rate of glucose oxidation by the enzyme, Deoxygenase.

In the plant runs reported, the hydrogen peroxide was used in excess of the amount required by the oxidation reaction, and consequently was not the predominant factor in controlling the rate of oxidation. The preferred level of hydrogen peroxide addition can be determined only after plant scale experimentation. The losses of oxygen to the atmosphere during processing will vary somewhat with the type of equipment used and the manner of addition. The most economic level of hydrogen peroxide is dependent upon the processing variables, as well as the relative cost of hydrogen peroxide and enzyme in their relationship to their influence on the rate of glucose oxidation.

The plant runs on the enzyme desugaring of egg white, under comparable conditions, indicate that the oxidation is reproducible and consequently results in a desugaring process which is easy to control. This reproducibility is illustrated in Figure 9. The uniform rate of decrease in sugar content, under similar processing conditions of fresh egg white as well as thawed frozen egg white, indicates the ease of control of this enzyme desugaring process.

SUMMARY

In summary, the Deoxygenase enzyme system containing glucose oxidase and catalase can, under suitable conditions, remove from food products either oxygen or glucose. The system has been applied with success to the desugaring of egg white in commercial size operations.

[b] The use of hydrogen peroxide as a source of available oxygen in the processing of egg white was first recommended to us by Dr. Dwight L. Baker of the Vita-Zyme Laboratories, Inc., Chicago, Illinois.

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The Complementary Action of Subtilin and Terramycin in Preserving Custard Fillings[a]

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Further studies on the preservation of custard fillings with subtilin and combinations of subtilin and terramycin have been investigated. Subtilin per se was effective in controlling the growth of the natural heat-resistant flora and the food-poisoning enterococci that were experimentally added to these fillings. It was necessary to use subtilin and terramycin in combination with each other in order to preserve the custard fillings against the experimentally added food-poisoning Salmonella bacteria and heat-resistant flora. The combined action of subtilin and terramycin was more effective against the heat-resistant spoilage flora, the pathogenic enterococci, and the micrococci than subtilin alone.

In a previous paper Godkin and Cathcart *(5)* reported that subtilin showed much promise in controlling the growth of experimentally added food-poisoning micrococci and those heat-resistant non-pathogenic bacteria which occur naturally in the prepared custard fillings. This preservative effect was greater when a small amount of terramycin was combined with the subtilin. Since these investigations dealt only with strains of one type of food poisoning organism, i.e., *Micrococcus pyogenes* var. *aureus*, additional studies were undertaken to determine what effect subtilin and combinations of subtilin and terramycin would have in preventing the growth of food poisoning strains of *Salmonella* and enterococci in custard fillings. Members of the *Salmonella* often have been implicated in food infection outbreaks with cream fillings *(2, 4, 6, 8)*, and to a lesser extent certain strains of the enterococci have been cited as causing food infection gastroenteritis *(2, 3, 4, 6)*. Further evidence of the occurrence of enterococci in custard filled bakery products is shown in the study made by Abrahamson *et al. (1)*.

The work reported in this paper deals specifically with two antibiotics, subtilin and terramycin. Prelimi-

[a] Practical use of these agents in foods is not permitted at the present time.

nary sensitivity tests showed that terramycin had the widest spectrum for antibacterial action against those strains of food poisoning micrococci, salmonellae, and enterococci that we possess. Subtilin was used because previous work had demonstrated its effectiveness against the natural heat-resistant food spoilage organisms that occur in a normally prepared custard filling *(5)*.

EXPERIMENTAL

Test organisms used. Strains of *Salmonella enteritidis*,[b] *Salmonella typhimurium*,[b] *Streptococcus faecalis*,[c] *Streptococcus liquefaciens*,[c] and *Micrococcus pyogenes* var. *aureus*,[d] which had been implicated in outbreaks of food poisoning, were used in this work. In a few tests a mixture of spores was utilized in conjunction with one or two food poisoning strains. This spore mixture had been prepared from cultures of 3 unidentified members of the genus *Bacillus* which originally had been isolated from spoiled custard filling controls that did not contain subtilin or terramycin.

Procedures. The preparation of the custard fillings and the method of adding the test organisms to these fillings were the same as outlined in a previous paper *(5)*. None of the fillings were autoclaved. The antibiotics[e] were incorporated by previous admixture with cornstarch. Stock admixtures of cornstarch and antibiotics were stored at 40° F. (4.5° C.). Incubation of the prepared fillings undergoing tests was maintained at 98.6° F (37° C.).

Differential plating media were used which varied according to the organisms being sought for recovery and/or growth in the fillings. *Salmonella* counts were made on Brilliant Green Agar (Difco). Doubtful colonies were picked and further tested in Friewer Shaughnessy Medium (Difco) and on Krumwiede Triple Sugar Agar (Difco) slants. Enterococci counts were made on SF Medium (Difco) with 1.5% agar added and also on Mitis Salivarius Agar (Difco). Staphylococcus Medium No. 110 was used for determining counts of *M. aureus*. The coagulase test was utilized in checking any doubtful *M. aureus* colonies. Stained smears were prepared and examined at X1000 whenever any doubt existed with respect to the identity of the colonies. It seldom was necessary to examine further the colonies from the original plating media since the only contaminants encountered were the heat-resistant spore-forming bacilli. A medium containing Tryptone Glucose Extract Agar (Difco) plus 1% Tryptose (Difco) was used as a standard plating medium with all strains. This medium gave excellent growth results with all of our test strains and was always used for a comparison count along with each differential plating medium.

RESULTS AND GENERAL DISCUSSION

The antibacterial effect of subtilin and combinations of subtilin and terramycin against 5 strains of organisms capable of producing food illness is shown in Table 1. Subtilin alone in concentration of 100 p.p.m. was effective in preserving the custard fillings against both strains of enterococci for at least 3 days. Following six days of incubation both fillings were slightly spoiled due to the growth of the heat resistant spoilage contaminants. (Spoilage by contaminants as expressed in this paper varied from a slightly sour aroma to an odor of putrefaction and was accompanied by a breakdown in the consistency of the filling.) Very little change in the *Str. liquefaciens* count was shown between the third and seventh day of incubation. The incorporation of terramycin in amounts of 1, 5, and 10 p.p.m. along with 100 p.p.m. of subtilin resulted in greater preserving action against *Str. faecalis* and *Str. liquefaciens*. While a combination of 100 p.p.m. of subtilin and 1 p.p.m. of terramycin was bactericidal to both strains of enterococci over an incubation period of 6-7 days, slight spoilage of the fillings did occur. This spoilage was caused by the slow growth of the heat-resistant contaminating bacteria. Increasing the terramycin concentration to 10 p.p.m. protected the custard filling from contaminant spoilage for approximately one week. The sensitivity of the enterococci to subtilin and terramycin somewhat parallels the sensitivity of the food poisoning micrococci to these antibiotics [see previous report *(5)*]. A concentration of 100 p.p.m. of subtilin and 1 p.p.m. of terramycin in custard fillings was bactericidal to the food poisoning strains of enterococci. However, this same combination of subtilin and terramycin had little effect against the test strains of *Salmonella* bacteria. Preliminary sensitivity tests had shown that the *S. typhimurium* and *S. enteritidis* test strains were very resistant to subtilin. When the terramycin concentration was increased to 5 and 10 p.p.m. the growth of both *Salmonella* strains was retarded considerably. The best preservative effect was obtained when subtilin was maintained at 100 p.p.m. and when the terramycin concentration was increased to 10 p.p.m. There was no advantage in increasing the terramycin concentration to 25 p.p.m. and holding the subtilin concentration at 75 p.p.m. Results, not recorded herein, showed that 10 p.p.m. of terramycin *per se* did not retard normal contaminant spoilage in custard fillings but 25 and 50 p.p.m. of terramycin delayed contaminant spoilage for 48 hours.

The use of 100 p.p.m. of subtilin and 5 p.p.m. of terramycin in a custard filling was bactericidal to *M. aureus* organisms and after 8 days' incubation the *M. aureus* count and spore count (not shown) was negligible.

In Table 2 are recorded the results showing the preservative effect of subtilin and terramycin combinations in custard fillings against mixed cultures of food poisoning bacteria and added aerobic bacterial spores. Although the addition of spores hastened the spoilage of the custard fillings, the antibiotic activity remained effective against the food poisoning organisms and their growth was inhibited for 3 days or longer. It is possible that when the aerobic heat-resistant spores were present in large numbers some germinated and utilized the subtilin. The remaining antibiotic activity against the *Salmonella* and *M. aureus* bacteria could have been due to the terramycin. When the contaminating aerobic spore count was low, i.e., 110 spores per g., subtilin-terramycin combinations of 100 p.p.m. and 10 p.p.m. or 75 p.p.m. and 25 p.p.m. respectively kept the uninoculated fillings from spoiling for one week. Without the incorporation of these antibiotics the uninoculated fillings spoiled within 24 hours.

[b] Courtesy of Dr. P. R. Edwards, Lexington Salmonella Center, Lexington, Kentucky.

[c] Strain numbers R5 and R26 by courtesy of Dr. C. F. Niven, Jr., American Meat Institute Foundation, Chicago, Illinois.

[d] Strain number 361 by courtesy of Dr. G. M. Dack, Food Research Institute, University of Chicago, Chicago, Illinois.

[e] Subtilin of 70% potency was obtained from Dr. H. S. Olcott of the Western Regional Research Laboratory, Albany, California. Terramycin Hydrochloride was purchased from a commercial source.

TABLE 1

Effect of subtilin and combinations of subtilin and terramycin in custard fillings containing food illness producing bacteria

Antibiotic	Concentration p.p.m.	Strain inoculum	Organisms × 10^8 added per g. filling	Organisms × 10^8 per g. filling for incubation time as shown				Remarks[1]
				24 hours	48 hours	72 hours	As shown	
Subtilin	100.0	*Str. faecalis*	0.07	<0.001	<0.001		6 days 1.30	Spoilage in six days
Subtilin	100.0	*Str. liquefaciens*	0.72	0.14	0.015	0.75	7 days 0.71	Very slight spoilage in seven days
Subtilin + Terramycin	100.0 + 1.0	*Str. faecalis*	0.07	<0.001	<0.001		6 days 0.0012	Slight spoilage in six days
Subtilin + Terramycin	100.0 + 1.0	*Str. liquefaciens*	0.72	0.005	<0.001	<0.01	7 days <0.01	Very slight spoilage in seven days
Subtilin + Terramycin	100.0 + 5.0	*Str. liquefaciens*	0.72	0.003	<0.001	<0.01	7 days <0.01	Same
Subtilin + Terramycin	100.0 + 10.0	*Str. liquefaciens*	1.15	<0.001	<0.001			No spoilage in 48 hours
Subtilin + Terramycin	100.0 + 10.0	*Str. faecalis*	0.14	<0.001	<0.001			Same
Subtilin + Terramycin	100.0 + 10.0	*Str. faecalis*	0.07	<0.001	<0.001		6 days <0.001	No spoilage within six days
None (Control)		*Str. faecalis*	0.07	5,050				Spoiled within 24 hours
None (Control)		*Str. liquefaciens*	0.72	24,000				Same
None (Control)		*Str. liquefaciens*	1.15	20				Same
None (Control)		*Str. faecalis*	0.14	260	6,080			Same
Subtilin + Terramycin	100.0 + 1.0	*S. typhimurium*	3.4	300	4,650			Slight spoilage within 48 hours
Subtilin + Terramycin	100.0 + 1.0	*S. enteritidis*	3	510	3,600			Same
Subtilin + Terramycin	100.0 + 5.0	*S. typhimurium*	2.6	0.25		0.2	8 days 7,800	Spoiled in eight days
Subtilin + Terramycin	100.0 + 5.0	*S. typhimurium*	1.56	0.27	2.3	70		No spoilage within 72 hours
Subtilin + Terramycin	100.0 + 10.0	*S. typhimurium*	3.4	0.8	<0.1	<0.01		Same
Subtilin + Terramycin	100.0 + 10.0	*S. typhimurium*	1.56	0.15	0.85	8		Same
Subtilin + Terramycin	100.0 + 10.0	*S. enteritidis*	3	<0.1	0.01	0.03		Same
Subtilin + Terramycin	100.0 + 10.0	*S. enteritidis*	5.44	0.35	0.004	0.13	7 days 0.2	Slight spoilage in seven days
Subtilin + Terramycin	75.0 + 25.0	*S. enteritidis*	5.44	2.93	0.31	0.2	7 days 1.19	Same
None (Control)		*S. typhimurium*	3.4	8,600				Spoiled within 24 hours
None (Control)		*S. enteritidis*	3	4,300				Same
None (Control)		*S. typhimurium*	2.6	18,000				Same
None (Control)		*S. typhimurium*	1.56	11,000				Same
None (Control)		*S. enteritidis*	5.44	15,000				Same
Subtilin + Terramycin	100.0 + 5.0	*M. aureus*	0.52		0.023	<0.001	8 days <0.001	No spoilage in eight days
None (Control)		*M. aureus*	0.52	8,600				Spoiled within 24 hours

In some instances there was not a definite correlation between the rate of spoilage and the contaminant count as shown in Table 2. Here it was thought that the spoilage by contaminants was due in part to anaerobic spoilage bacteria. In several spoiled fillings the presence of anaerobic bacteria was detected; however, no attempts were made to determine their numbers.

Jann *et al. (7)* have stated that in order to minimize the development of resistant strains, minimum concentration levels of each antibiotic must be maintained, even when the 2 antibiotics are used in combination. The work in this report and a previous one *(5)* indicate that the growth of the pathogenic food poisoning bacteria experimentally added to the custard fillings could have been controlled by lesser amounts of subtilin and terramycin in combination than those amounts used or by terramycin alone (5-10 p.p.m.) if it were not for the natural presence of heat-resistant spoilage contaminants in the prepared fillings. At present information is not available on the sporicidal activity of terramycin when used in concentrations above 50 p.p.m. in custard fillings.

The incubation of custard fillings at 98.6° F. (37° C.) was favorable to the growth of the food poisoning bacteria used in this work and also to the normal heat-resistant flora. Consequently it is believed that under average room temperature storage the complementary antibiotic activity of subtilin and terramycin would be enhanced. It is the authors' view that the addition of 100 p.p.m. of 70% potency subtilin and 10 p.p.m. of terramycin to a custard filling will retard the growth of food poisoning strains of enterococci, salmonellae, micro-

TABLE 2

Effect of combinations of subtilin and terramycin in custard fillings against mixed cultures of food poisoning organisms and added spores

Antibiotic	Concentration p.p.m.	Strain inoculum	Organisms × 10^6 added per g. filling	Organisms × 10^6 per g. filling for incubation time as shown				Remarks[c]
				24 hours	48 hours	72 hours	As shown	
Subtilin + Terramycin	100.0 ‡ 10.0 §	*S. typhimurium* *M. aureus*	3.85 1.1	0.23 0.2	0.01 0.01	0.004 0.002	7 days 0.023 <0.001	No spoilage in seven days
Subtilin + Terramycin	100.0 ‡ 10.0 §	*S. typhimurium* *M. aureus* Spore mixture[a]	6 1.2 0.2	1.5 0.1 1.3	0.34 <0.01 190		10 days 480 <0.01 1,520	Spoiled within 48 hours
Subtilin + Terramycin	100.0 ‡ 10.0 §	*S. typhimurium* *M. aureus* Spore mixture[a]	6 1.2 0.15	1.48 0.3 2	0.08 <0.01 160		10 days 500 <0.01 900	Same
None (Control)		*S. typhimurium* *M. aureus*	3.85 1.1	25,000 7,300				Spoiled within 24 hours
None (Control)		*S. typhimurium* *M. aureus* Spore mixture[a]	6 1.2 0.2	31,000 3,700 60				Same
None (Control)		*S. typhimurium* *M. aureus* Spore mixture[a]	6 1.2 0.15	16,000 7,500 60				Same
None (Control)		No inoculum	0.006[b]	3,150				Same
None (Control)		Spore mixture[a]	0.15	7,300				Same
Subtilin + Terramycin	100.0 ‡ 10.0 §	*S. enteritidis* Spore mixture[a]	5.44 0.165	0.13 3.2	0.009 137	0.28 440	7 days 37 350	Spoiled within 48 hours
Subtilin + Terramycin	75.0 ‡ 25.0 §	*S. enteritidis* Spore mixture[a]	5.44 0.165	1.73 0.005	0.28 187	0.1 340	7 days 0.54 50	Same
None (Control)		*S. enteritidis* Spore mixture[a]	5.44 0.165	13,000 90				Spoiled within 24 hours
None (Control)		No inoculum	0.00111[b]	490				Same
Subtilin + Terramycin (Control)	100.0 ‡ 10.0 §	No inoculum	0.00111[b]	<0.001	<0.001	<0.001	7 days <0.001	No spoilage in seven days
Subtilin + Terramycin (Control)	75.0 ‡ 25.0 §	No inoculum	0.00111[b]	<0.001	<0.001	<0.001	7 days <0.001	Same

[a] Mixture of spores added to cooled fillings.
[c] Mixture of spores added during preparation of fillings.
[b] Natural spore count.

cocci, and also the normal heat-resistant spoilage organisms for a period of 3 days at summer temperatures.

SUMMARY

Results are presented to show the preserving action of subtilin and subtilin-terramycin combinations in custard fillings. The growth of food-poisoning strains of *Salmonella* bacteria and natural heat-resistant flora in custard fillings incubated at 98.6° F. (37° C.) was retarded for at least 72 hours by the addition of 100 p.p.m. of 70% potency subtilin and 10 p.p.m. of terramycin. Subtilin alone of 70% potency in concentration of 100 p.p.m. retarded the growth of food-poisoning enterococci and the natural heat-resistant flora in custard fillings for 72 hours. A longer preserving effect (6-7 days) against these food poisoning enterococci was obtained by combining 100 p.p.m. of 70% subtilin with 1 p.p.m. of terramycin in the fillings. The preserving action of subtilin and combinations of subtilin and terramycin in custard fillings against food-poisoning enterococci is similar to the anti-bacterial activity of these antibiotics towards food-poisoning micrococci reported herein and elsewhere (5).

When aerobic bacterial spores and food poisoning bacteria were added to custard fillings containing subtilin and terramycin the rate of spoilage was hastened but the growth of pathogenic bacteria was retarded for 3 days or longer. It is believed that the increased rate of spoilage was due to the utilization of the subtilin by the heat-resistant flora and that the remaining antibiotic activity against the pathogenic organisms was due to the terramycin.

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Resistance Values Reflecting the Order of Death of Spores of Bacillus coagulans Subjected to Moist Heat[a]

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This paper presents results of a study designed to obtain information bearing on the order of death of spores of Bacillus coagulans subjected to moist heat. Data presented show that, under the conditions of the study, the order of death was logarithmic. This finding is discussed in view of the experimental methods employed in the study and in view of published information on the subject.

The newer methods for evaluating thermal processes for canned foods *(5, 6, 14, 16)* are based on the concept that the order of death of bacteria subjected to moist heat is logarithmic. Experimental results have been presented *(1, 2, 3, 11,* and others) which would appear to refute this concept. On the other hand, much evidence has been presented *(4, 9, 10,* and others) which strongly supports it. Regardless of what the order of death may be found to be, it is of utmost importance that further information bearing on the point be obtained. The importance lies in the fact that the accuracy of calculated process specifications for heat processed foods depends directly on such information.

Bacillus coagulans (*Bacillus thermoacidurans*, Berry), the organism chosen for this study, frequently has been the cause of spoilage of economically important amounts of canned foods, acid foods (pH 3.7 to 4.5) such as tomatoes and tomato products being the most commonly involved *(7, 8, 13)*. A report *(1)* which appeared recently relating to the thermal resistance of this organism presented rate of destruction curves which were not straight lines as plotted in the conventional manner. It seemed possible that the nature of these curves might have been due to a number of factors associated with the experimental methods employed in obtaining the data upon which the curves were based, possibly to some of the factors suggested by Rahn *(9, 10)* as causing divergence of rate of destruction curves from straight lines. It was therefore considered expedient to attempt, by a rather recently developed experimental technique *(15)*, to determine the order of death of spores of *B. coagulans* subjected to moist heat. It is the purpose of this paper to present a brief description of the technique employed and a summary of the results obtained.

EXPERIMENTAL

Design of experiment to determine order of death. In process calculation, the symbol "D" is used to represent the slope of the straight-line rate of destruction curve. It is defined as the number of minutes required for the curve to traverse one log cycle, the curve being obtained by plotting, on semi-logarithmic paper, the number of surviving cells (vegetative or spore) in the direction of ordinates against time of heating at a given temperature in the direction of absicissae. If the rate of destruction curve were straight, as assumed in the above definition, the logarithmic order of death would be indicated, and values of "D" for any concentrations of organisms subjected to a given temperature would have to be constant. In other words, the time required to destroy a given fraction would have to be independent of concentration.

This study was therefore so designed that 4 different concentrations of spores of *B. coagulans* were subjected to each of 4 temperatures — 220° F. (104.4° C.), 225° F. (107.2° C.), 230° F. (110° C.), and 235° F. (112.7° C.). The concentrations, arranged in decreasing order, were as follows: the second 0.1 of the first, the third 0.1 of the second, and the fourth 0.1 of the third (the highest thus being 1,000 times the lowest). It was believed that, by employing such widely different concentrations, the "D" values ascertained would reflect the nature of death of the spores, e.g., if the "D" values ascertained were constant it would definitely indicate that death of the spores had occurred logarithmically. The experiment was designed so that significance of differences among "D" values obtained could be tested by subjecting them to an analysis of variance.

Production and handling of spore suspensions. Protease-peptone acid agar as developed by Stern, Hegarty, and Williams *(13)* was employed throughout for production of the spores of *B. coagulans*[c] and for its subculture from heated samples. It was prepared according to modifications in method introduced by Anderson, Esselen, and Fellers *(1)*.

Slants of the protease-peptone acid agar were inoculated from the original culture and incubated at 131° F. (55° C.) until growth was abundant (2 to 3 days). The cultures were then washed from the slants with sterile distilled water. Two ml. of this suspension were transferred to each of a number of 6-ounce screw-cap bottles containing 40 ml. of the acid agar. (The agar had previously been allowed to solidify while the bottles were on their sides.) The inoculum was spread over the surface of the agar and the bottles incubated at 131° F. (55° C.) for 2 weeks to obtain maximum spore production. At the end of this period the growth was washed from the surface with sterile distilled water. The resulting suspension was mixed for 5 minutes in a sterile Waring blendor. It was then poured through a gauze-cotton-gauze filter into sterile 6-ounce screw-cap bottles containing about one-half inch of glass beads. This suspension was kept stored at 40° F. (8.5° C.) and served as stock throughout the study.

A method *(17)*, in which the thermoresistometer *(15)* was used for destroying vegetative cells and activating spores, was employed for estimating the spore concentration of the stock suspension. The heat treatment consisted of exposing sample aliquots of the suspension to 220° F. (104.4° C.) for 0.14 minutes. This time-temperature relationship was determined experimentally and represents that which gave maximum spore counts (based on 3 replicate determinations). The number of spores per ml. of the stock spore suspension was estimated to be 1,010,000. This value was the average of counts obtained from 5 replicate determinations made on different days.

Preparation, heating and subculture of samples. Samples were prepared by transferring to thermoresistometer cups 0.02 ml. quantities from the stock spore suspension, and from a 1:10, 1:100, and 1:1000 dilution, respectively, of the stock suspension.

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[c] *B. thermoacidurans* (Strain 43 P) obtained from Mr. C. Wallace Bohrer, National Canners Association laboratories, Washington, D. C.

(All dilutions were made with sterile distilled water and violently agitated immediately before samples were removed.) The resulting concentrations, based on the count estimated for the stock spore suspension, were *20.2*, *202*, *2,020*, and *20,200* spores per 0.02 ml. sample. Six replicate lots of samples representing each spore concentration were subjected to *220°* F. (104.4° C.), 6 lots to *230°* F. (110° C.), 3 lots to *225°* F. (107.2° C.), and 3 lots to *235°* F. (112.7° C.). Six samples from each lot were subjected in the thermoresistometer to each time-temperature relationship, 7 heating times being employed at each temperature for each spore concentration used. The times were such that none of the samples subjected to a given temperature for the shortest time was sterilized, but all which were subjected to the given temperature for the longest time were sterilized. Between the shortest and longest times a number of intermediate times were employed which resulted in a number but not all of the 6 samples, subjected to the given temperature, being sterilized.

Each heated sample was ejected from the thermoresistometer into a tube of the protease-peptone acid agar (approx. 20 ml.) referred to above. All subculture tubes so obtained were incubated at 98° F. (37° C.) until a period of 10 days elapsed during which no growth appeared in tubes negative for growth prior to the beginning of the 10 day period.

Treatment of data. From recorded observations of growth from subculture it was possible to calculate by methods described elsewhere *(17)*, the most probable number of spores surviving a number of the time-temperature relationships. Knowing the initial number of spores per sample and the most probable number of spores surviving a given time-temperature relationship, it was possible to calculate, as described previously *(17)*, the time required at a given temperature to destroy 90% of the spores. This method of calculation assumes the order of death to be logarithmic, and the time at a given temperature to destroy 90% of the spores ("D" value) should be constant, irrespective of spore concentration in the samples, if the assumption is correct. Statistics were applied to the data obtained to determine by an analysis of variance *(12)* the constancy of "D" values calculated for the different concentrations of spores subjected to any given temperature.

RESULTS AND DISCUSSION

The "D" values obtained as described above appear in Table 1. Constancy of the "D" values for the spores, in the indicated concentrations, subjected to each of the 4 temperatures was determined statistically by means of an "F" test based on the hypothesis that there was no effect on the "D" values due to different spore concentrations. In order for this hypothesis to be accepted the "F" value for *220°* F. (104.4° C.) or *230°* F. (110° C.) had to be less than *3.29*, and that for *225°* F. (107.2° C.) or *235°* F. (112° C.) less than 4.07. The "F" value for *220°* F. was found to be 0.70, that for *225°* F. to be *2.20*, that for *230°* F. to be *2.25*, and that for *235°* F. to be 1.90 (see Table 1). Therefore, unless a chance more remote than 1 in 20 (basis for acceptance of hypothesis) occurred, the "D" values obtained are constant for the different spore concentrations subjected to each of the 4 temperatures employed, i.e., under the conditions that obtained in this study, the order of death of spores of *B. coagulans* was logarithmic.

As pointed out earlier there is considerable evidence that, at least for some species of bacteria when subjected to moist heat, the true order of death is logarithmic. Results of this study add to this evidence; however, it should be emphasized that this study has been far too limited to justify more than moderate speculation as to the order of death of bacteria in general. It is believed that the careful blending and filtration of the stock spore suspension before storing it, and the violent agitation (with glass beads) given it before each use, aided greatly in removing spore clumps and thereby contributed to the nature of the results reported here. Also, it is felt that the thermoresistometer technique allowed for more precise measurements of heat applied than would have been possible by a number of other methods in current use for studying spore resistance. Applying a predetermined amount of heat for activating spores in obtaining spore counts certainly contributed as well to the nature of the results obtained.

TABLE 1

Rate of destruction values for four concentrations of spores (number per six sample lot) B. coagulans subjected to the indicated temperatures

Replication	"D" Values for Spores Subjected to 220° F. in Concentrations of:				"D" Values for Spores Subjected to 225° F. in Concentrations of:			
	121,2	1,212	12,120	121,200	121,2	1,212	12,120	121,200
1	1.81	1.85	1.74	1.73	0.84	0.90	0.86	0.96
2	1.64	1.84	1.75	1.70	0.88	0.85	0.89	0.90
3	1.53	1.77	1.61	1.68	0.83	0.93	0.89	0.90
4	1.53	1.92	1.76	1.71				
5	1.65	1.83	1.74	1.70				
6	1.69	1.77	1.61	1.75				
Average D Value	1.64	1.83	1.70	1.71	0.85	0.89	0.88	0.92
Obs. F	0.70				2.20			
Expt. $F_{.05}$	3.29				4.07			

Replication	"D" Values for Spores Subjected to 230° F. in Concentrations of:				"D" Values for Spores Subjected to 235° F. in Concentrations of:			
	121,2	1,212	12,120	121,200	121,2	1,212	12,120	121,200
1	0.314	0.323	0.286	0.262	0.172	0.173	0.162	0.195
2	0.293	0.361	0.258	0.376	0.189	0.174	0.172	0.188
3	0.353	0.348	0.277	0.385	0.171	0.197	0.185	0.188
4	0.289	0.222	0.266	0.352				
5	0.412	0.309	0.258	0.316				
6	0.296	0.440	0.311	0.370				
Average D Value	0.352	0.334	0.276	0.344	0.177	0.181	0.173	0.190
Obs. F	2.25				1.90			
Expt. $F_{.05}$	3.29				4.07			

SUMMARY

The study described was designed to obtain information on the order of death of spores of *B. coagulans* when subjected to moist heat. Spores of the organism were subjected (in concentrations of 121.2, 1,212, 12,120, or 121,200 per each 6-sample lot) to temperatures of 220° F. (104.4° C.), 225° F. (107.2° C.), 230° F. (110° C.) and 235° F. (112° C.) in order to determine the time required at each of the temperatures to destroy 90% of the spores in each of the lots having the different spore concentrations. The "D" values ascertained for the different spore concentrations subjected to any one of the temperatures were analyzed statistically to determine significance of differences among them. No significance was found for differences in "D" values representing rates of destruction of spores subjected to any of the four temperatures. It was concluded that the logarithmic order of death was indicated by all the data obtained.

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Quality and Nutritive Properties of Different Types of Commercially Cured Hams. III. Vitamin Content, Biological Value of the Protein and Bacteriology[a]

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In previous papers the curing methods, chemical composition, and organoleptic properties of commercially cured hams have been described (4, 14). This paper presents further information on the same samples, in respect to certain vitamins, the biological value of the protein and bacterial content.

Commercially cured hams are prepared by 4 typical methods: I, sweet pickle, quick-cured, tendered; II, sweet pickle, quick-cured, ready-to-eat; III, sweet pickle, long cured; and IV, the dry-cured Smithfield process. When possible, 5 samples of each type of cured ham were obtained from a small, an intermediate-sized, and a large packing company. This made a total of 15 samples representing each type of cure. Hereafter, designations I, II, III and IV will be used in referring to the different types of cured hams.

VITAMIN ANALYSES

In preparing samples for vitamin analyses, the hams were trimmed free of fat, and all of the lean was ground 3 times

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through a fine food chopper with careful mixing after each grinding.

Extraction of thiamine and riboflavin was carried out on the same extract simultaneously, using methods similar to those described by the Association of Vitamin Chemists *(1)*. The extract was prepared by homogenizing the ground sample with hydrochloric acid at pH 1.4 in a Waring Blendor. Aliquots of the slurry were heated for one hour in a boiling bath. Samples were cooled and adjusted to pH 4.6 by adding a sodium acetate buffer, containing both takadiastase and papain. Enzymatic digestion was carried out at 96.8° F. (36° C.) for 48 hours, after which the samples were filtered. Thiamine was determined by the fluorometric methods of Hennessey and Cerecedo *(6)* and Conner and Straub *(2)*, as described in the United States Pharmacopoeia *(9)*. Riboflavin was assayed fluorometrically, using modifications of the methods of Conner and Straub *(2)*, with modifications for use with cured pork essentially as described in the book *Methods of Vitamin Assay (1)*.

Niacin was determined by the microbiological method of Snell and Wright *(13)*, with modifications as described by the Association of Vitamin Chemists *(1)*.

The vitamin values ranged greatly among the individual samples. In the case of thiamine the range was from 6.6 to 63 micrograms per g. protein; riboflavin 2.8 to 18.6; and niacin 7.3 to 341. Similar large variations have been reported in the literature *(3, 5, 8, 10, 12)*. Rice, Fried and Hess *(11)*, in 2 tests, showed vitamin variations for thiamine from 28.5 to 83.4 micrograms per g. of protein, for riboflavin from 5.5 to 7.4, and for niacin from 140 to 465.

The results shown in Table 1 indicate that cured hams are an excellent source of thiamine, niacin, and riboflavin. The vitamin content has been calculated on a protein basis. In view of the wide variation in vitamin content of the individual samples, it is of interest that the average values for each type of cured hams are in rather good agreement. Results are not strictly comparable, however, since the original values before processing are not known. From inspection of the data there appear to be some significant differences between the average vitamin content of the samples shown in Table 1. Yet when subjected to statistical analysis, these differences are shown to be insignificant at the 5% level, with the exception of the niacin value of Type IV hams which is about 50% higher than in the other types. Hams used in the Smithfield type process are usually obtained from hogs fed a high peanut diet, which contains 2 to 3 times as much niacin as does a corn diet. The sweet pickle, long cured hams (Type III) produced by small packing company D, showed significantly higher niacin values, than did the hams produced by companies A and E.

BIOLOGICAL VALUE OF THE PROTEIN

Samples were prepared by "boning" 4 hams, removing the separable lean, freezing overnight at 0° F. (−17.8° C.), grinding while frozen, and immediately drying at 120° F. (48.9° C.) for 6 hours, to below 10% moisture. The dried lean meat was ether extracted and added to the rations for the rats to give 10% protein. Fresh hams were obtained from normal 225-pound hogs, fed basically on a corn diet. The fresh samples were prepared for biological testing in a manner identical to that used with the cured samples. In the determination of the biological value of the protein, the diets were made up as shown in Table 2. On account of the variation in sodium chloride content of the different lots of hams, each diet was adjusted to 3.15% salt. The term "biological value" denotes the average gain in weight of 8 male albino rats in 30 days for each gram of nitrogen consumed.

Using the results on the fresh hams (18.3 g. gain per g. nitrogen consumed), from Table 3, as a basis for comparison, the tendered Type I hams had a value of 100%, the ready-to-eat Type II hams showed a value of 92.3%, for the Type III long-cured hams the value was 103%, and the Smithfield Type IV hams were 94.5% of the fresh. Apparently the commercial methods of curing hams had little detrimental effect upon the biological value of the protein. One lot of Type II hams, produced by a small packing company, had an unusually low biological value. The comparisons, when subjected to statistical analysis, proved to be insignificant at the 5% level.

BACTERIOLOGICAL STUDIES

Samples were taken about 5 inches anterior to the butt end of the ham. First the skin and fat layer were aseptically removed and discarded. The exposed ham was well seared with a hot spatula, and a wedge of lean tissue removed with a sterile scalpel. In removing the sample, cuts were made with the scalpel to the femur bone. Ten g. from the portion adjacent to the femur bone were transferred to a sterile Waring Blendor jar. Ninety ml. of sterile 5% sodium chloride solution were

TABLE 1

Vitamin analyses of cured and fresh hams*

Types of cure	Thiamine	Number of samples	Riboflavin	Number of samples	Niacin	Number of samples
I						
A, large	31.3	5	6.8	5	199	4
B, intermediate	34.0	5	9.0	4	181	4
D, small	26.2	5	7.7	4	167	4
II						
A, large	32.6	4	8.9	4	147	5
B, intermediate	30.4	4	8.3	4	214	4
C, small	25.5	4	7.8	4	149	4
III						
A, large	30.7	3	7.6	2	126	2
D, small	28.3	5	8.8	4	247	3
E, small	31.9	3	9.1	2	115	2
IV						
F, intermediate	22.3	5	8.3	5	310	5
G, intermediate	30.8	5	12.6	5	280	5
H, intermediate	25.5	5	10.3	5	295	4
Average						
I Tendered	30.5	15	7.7	13	180	12
II Ready to eat	29.5	12	8.3	12	168	13
III Long cured	29.7	11	8.6	8	173	7
IV Smithfield process	26.2	15	10.4	15	248	14
Fresh	29.4	5			224	5

* Figures represent average values in micrograms of vitamin per g. of protein. The capital letters A, B, C, D, E, F, G and H represent 8 different processing companies from which the hams were obtained.

TABLE 2

Composition of rations used in determining the biological value of the protein

	%	B vitamins added to 100 g. of ration	mg.
Dehydrated, ether extracted ham, sufficient to supply 10% protein		Thiamine hydrochloride	0.3
Salt mixture[f]	2.00	Riboflavin	0.3
Sodium chloride to make 3.15% of ration		Pyridoxine hydrochloride	0.6
B vitamins in dextrin	2.50	Calcium pantothenate	1.5
Fat soluble vitamin in lard	1.00	Niacin	5.0
Lard to make total fat 10%		Choline chloride	40.0
Dextrin (Amidex) to make 100%		Para aminobenzoic acid	7.5
		Inositol	20.0
		Liver extract	375.0
		Biotin	0.02
		Folic acid	0.04

Fat soluble vitamins in 100 g. of ration

A (distilled vitamin A concentrate)	500 U.S.P. units
D (viosterol	100 U.S.P. units
E (Alpha tocopherol)	2.0 mg.
K (2 methylnaphtha quinone)	0.2 mg.

[f] U. S. Dept. Agr. *Tech. Bull.* 725, 1949, p. 4 (*7*).

TABLE 3

Biological values of protein in cured and fresh hams[e]

Description of hams	Average gain in weight	Average feed consumed in 30 days	Feed per g. in weight	Gain per g. of nitrogen
	grams	*grams*	*grams*	*grams*
Type I				
A, large	74	274	3.70	16.9
B, intermediate	85	286	3.34	18.8
D, small	84	274	3.28	19.4
				Average 18.3
Type II				
A, large	82	285	3.42	18.0
B, intermediate	78	268	3.54	18.0
C, small	60	251	4.22	14.8
				Average 16.9
Type III				
A, large	80	271	3.41	18.4
D, small	91	290	3.20	19.6
E, small	80	262	3.30	18.7
				Average 18.9
Type IV				
F, intermediate	74	276	3.76	16.7
G, intermediate	80	284	3.58	17.6
H, intermediate	79	280	3.55	17.6
				Average 17.3
Fresh	80	272	3.48	18.3

[e] The capital letters A, B, C, D, E, F, G and H represent 8 different processing companies from which the hams were obtained.

added and the mixture blended for 30-45 seconds. The 1 to 10 ham mixture was further diluted when considered necessary, with 5% saline. Plates were poured from the desired dilution, using veal infusion agar with 5% sodium chloride added. Counts were made after incubation for 48 hours at 98.6° F. (37° C.) and after 5 days at 68° F. (20° C.). Prior to counting the plates, transfers to agar slants were made from colonies appearing to represent the most prevalent microorganisms.

Results indicated in Table 4, showed no count in 11 out of 14 Type I hams, 2 with an insignificant number of bacteria (10 and 600 bacteria per g.), and 1 with 2,000,000 bacteria per g. Our laboratory has arbitrarily set a value of less than 1,000 bacteria per g. as an insignificant number of bacteria. Nine out of 12 Type II hams showed no count, 2 had insignificant numbers (10 bacteria per g., each), and 1 ham had 40,000 bacteria per g. Type III hams showed 3 samples with no count out of 11 examined, 4 with insignificant numbers (15 to 500 per g.) and 4 hams with significantly high bacterial counts (16,500; 215,000; 150,000; 2,350). The Smithfield Type IV hams had 11 out of 15 with no count, 3 with insignificant numbers(10 to 440 per g.), and one sample with 50,000.

It is interesting to note that Type I, II and IV hams yielded no count well over 70% of the time, and over 90% had 1,000 or fewer bacteria per g. It seems likely that in pumping Types I, II and III hams, prior to curing, even if sterile pumping pickle had been used, some bacterial contamination would have been introduced into the hams. Later, heat treatment during

TABLE 4

Numbers of bacteria in commercially cured hams

Hams	Types of ham				
	I Tenderoi	II Ready to Eat	III Long Brine	IV Smithfield	Total
Number tested	14	12	11	15	52
With more than 1000 bacteria per g.	1	1	4	1	7
With 10 to 1000 bacteria per g.	2	2	4	3	11
With no count	11	9	3	11	34
Percent with more than 1000 bacteria per g.	7.1	8.3	36.4	6.7	
Percent with 10 to 1000 bacteria per g.	14.3	16.7	36.4	20.0	
Percent with no count	78.6	75.0	27.2	73.3	
Percent with 1000 or less bacteria per g.	92.9	91.7	63.6	93.3	

smoking Types I and II hams destroys many organisms present, but in the case of Type III hams which are not heated much above 120° F. (48.9° C.), no reduction of bacterial numbers occurs, and hence the low percent (27.2) of hams having no count. The Type IV Smithfield hams, like most fresh hams, were probably sterile initially. Since pumping is not part of the processing, with subsequent higher salt concentrations after curing and storage, the hams either remained sterile or any bacteria which may have penetrated with the curing ingredients, were too few to count by the technique employed.

A majority of the bacteria found in these hams were nonpathogenic micrococci. The final identification of the organisms is the subject of a current study.

Conclusions from our bacteriological results show that commercial curing procedures, in general, produce hams which are wholesome from the standpoint of both numbers and types of bacteria found.

SUMMARY

Commercially cured hams are very good sources of certain of the B vitamins. Analyses of 53 samples for thiamine showed an average value of 29.0 micrograms per g. of protein, with a range from 6.6 to 63.0. Forty-eight samples analyzed for riboflavin had 8.8 micrograms per g. of protein with a range from 2.8 to 18.6. The average niacin content of 46 samples was 193 micrograms per g. of protein, with a range from 73 to 341.

The typical commercial curing methods, which were used, resulted in the retention of well over 90% of the biological value of the protein.

In bacteriological examination of cured hams 34 out of 52 showed no count, and 45 had less than 1000 bacteria per g.

The typical commercial ham curing methods had little deleterious effect on vitamin content or biological

value of the protein, and produced products which were bacteriologically sound.

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Elimination of Salmonella in Whole Egg Powder by Cathode Ray Irradiation of Egg Magma Prior to Drying[a,b]

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Salmonella organisms in heavily inoculated whole egg magma were completely destroyed by cathode ray irradiation. The level of irradiation necessary for complete destruction varied according to the Salmonella species. S. paratyphi and S. typhimurium required substantially higher irradiation levels than did S. senftenberg. The irradiation level necessary for Salmonella destruction caused an off-flavor, which was detectable in scrambled eggs prepared from irradiated egg magma. When this irradiated egg magma was spray dried, subsequently rehydrated, and offered to a taste panel as a scrambled egg dish, there was no significant preference for either irradiated or non-irradiated eggs. Irradiation at levels necessary for complete destruction of Salmonella in whole egg magma had no effect on the baking quality as measured by volume and organoleptic properties of sponge cakes.

Dried egg powders may frequently contain viable bacteria of the *Salmonella* group. The danger of infection from this source has caused increasing concern to those interested in safeguarding the health of the egg-consuming public. In a recent review dealing with the subject of *Salmonella* infections in food products, Hinshaw and McNeil *(4)* indicated that whole egg powders have been suspected as being the cause of numerous outbreaks of *Salmonella* infection in human consumers.

Gibbons and Moore *(2)* examined dried whole egg powders produced in Canada during the period from November 1942 to December 1943 and found viable *Salmonella* organisms in 28 of 380 samples. Among these, 9 types were found. Of 21 samples on which *Salmonella* counts were made, one contained as many as 54 of these organisms per g. and 7 contained between 1 and 10 per g.

During 1945, Gibbons *(1)* isolated *Salmonella* organisms (other than *S. pullorum*) from 28% of 400 Canadian dried whole egg powders that were examined. The most probable number of these *Salmonella* organisms in the majority of the samples was less than one per g., and the species most often found were *S. oranienburg* and *S. typhimurium*. *S. pullorum* was isolated from 4% of the samples.

Some investigators have indicated that *S. pullorum* is not pathogenic for man, but McCullough and Eisele *(5)* fed strains of this organism isolated from whole egg powders to human volunteers and reported pathogenicity with heavy inocula. Evidence is also given in the review by Hinshaw and McNeil *(4)* to the effect

[a] Presented at the Dehydrated Egg Symposium sponsored by the National Research Council, Advisory Board on Quartermaster Research and Development, Committee on Foods, Subcommittee on Animal Products, held in Chicago, Ill., Feb. 12-13, 1953.

[b] Contribution No. 147, Department of Food Technology, Massachusetts Institute of Technology, Cambridge.

that human Salmonellosis is not caused by any particular species. The prevailing opinion of current investigators is that all species of *Salmonella* are pathogenic for humans.

Solowey and Calesnick *(7)* found that *Salmonella* strains multiplied rapidly in reconstituted eggs held at temperatures from 77° to 113° F. (25° to 45° C.) and concluded that these organisms might reach levels considered hazardous from a health standpoint if the reconstituted eggs were held at room temperature for a period of more than 4 hours. They also found that *Salmonella* were able to survive temperatures used in the preparation of soft (lightly) scrambled eggs.

Hence, even though the level of contamination may be low initially, short holding periods can cause the level of infection to assume dangerous proportions rapidly. This is especially significant when it is realized that many of our foods containing eggs receive only light cooking, which is insufficient to kill the *Salmonella*, and these foods are frequently fed to children, who are particularly susceptible to Salmonellosis.

Since the latter part of 1944, when the Quartermaster Corps required pasteurization in their specifications for the preparation of dried whole eggs, most manufacturers have included a preheating treatment at 140° F. (60° C.) just prior to spray drying. However, because egg proteins are highly heat sensitive, minimum pasteurization times are used, and there is some question whether all *Salmonella* organisms can be destroyed by such treatment, especially at high levels of contamination. Current pasteurization specifications call for a 2-minute holding period at 140° F. (60° C.).

Winter *et al. (10)*, using a laboratory model of an experimental pasteurizer, found *S. senftenberg* and *S. cerro* to be the most heat resistant and *S. pullorum* the least heat resistant of the *Salmonella* types examined. Strains of *S. senftenberg* that did not darken Kligler's iron agar were more resistant than those that did. With the exception of these 2 species, all the *Salmonella* types studied were destroyed in liquid whole egg within 2.6 minutes at a temperature of 140° F. (60° C.). *S. senftenberg* was destroyed after being heated for 6.7 minutes at 140° F. (60° C.). In obtaining these data, Winter *et al. (10)* used liquid whole eggs inoculated with a mixture of aged cells of different *Salmonella* species at levels of 40,000 to 1,000,000 organisms per ml.

Goresline *et al. (3)* reported that with careful attention to operating procedures, liquid whole eggs could be flash-heated to 140° F. (60° C.) and held at that temperature for 3 minutes to kill any *Salmonella* organisms present, without appreciably affecting the functional qualities of the egg product. These results were obtained with commercial egg products without prior inoculation with *Salmonella* cultures.

Winter *(9)* found that more than 99% of all coliform and *Salmonella* organisms were destroyed by heating whole egg or yolk for 4 minutes at 140° F. (60° C.) or for 2 minutes at 142° F. (61.1° C.) and by heating egg white at 134° F. (56.7° C.) for 2 minutes. He found that the keeping quality of such products was improved by pasteurization, especially when they were held under food refrigerator conditions. The volume of cakes made with heated egg products was slightly reduced and the beating time was increased, but such changes were not considered objectionable. Pasteurization did not significantly change the properties of whole eggs when used for scrambling, custards, or mayonnaise.

Recent data obtained at the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Ill. (personal communication) indicate that heating at 140° F. (60° C.) for 3 minutes may not be sufficient to destroy all *Salmonella* in liquid eggs. This problem is being actively studied at the present time.

Previous research in the Department of Food Technology, Massachusetts Institute of Technology, has indicated that cathode rays produced by a Van de Graaff electrostatic generator can be used effectively for the pasteurization and sterilization of numerous food products *(6)*. Accordingly, exploratory experiments were planned to determine the feasibility of substituting a cathode ray irradiation procedure for the current thermal pasteurization of liquid whole egg prior to spray drying.

As cathode ray irradiation is essentially a cold sterilization, thermal denaturation is not a problem. However, cathode ray irradiation sometimes causes off-flavors. The development of irradiation flavor is dependent both on the nature of the substrate and the intensity of the cathode ray irradiation. Therefore, the feasibility of this procedure of eliminating *Salmonella* is dependent on whether the flavor development, at the level of irradiation necessary for sterility, is sufficient to be objectionable to consumers from a taste standpoint.

It has been noted in previous experiments on cathode ray irradiated foods that the off-flavors sometimes dissipate on standing and that this loss of the irradiation flavor is aided by conditions favoring aeration. It was felt that the aeration and vaporization occurring during the spray-drying operation represent a condition that would be highly favorable to the loss of such flavors, if such were developed at the necessary levels of irradiation. Experiments were therefore designed to provide information regarding the following questions:

(a) What is the dose of cathode rays required to sterilize liquid whole egg that is heavily contaminated with various species of *Salmonella*?

(b) What effect does this sterilization treatment have on the flavor of liquid whole egg?

(c) What effect does spray-drying have on the flavor of whole egg magma that has been sterilized by cathode rays?

(d) What effect does sterilization by cathode ray irradiation have on the baking quality of liquid whole egg?

METHODS AND PROCEDURE

For determination of the sterilizing dose of cathode rays, blended whole egg magma from fresh eggs was inoculated with 24- or 48-hour cultures of *S. paratyphi* ATCC 9444, *S. typhimurium* ATCC 9148, or *S. senftenberg* 775 W, and poured in 7-ml. amounts into sterile beakers. The beakers were covered with sterile aluminum foil and subjected to cathode ray irradiation produced by a 3 m.e.v. Van de Graaff generator *(8)*. Ten

such samples were irradiated at any one level of cathode ray irradiation. The doses ranged from 50,000 to 500,000 rep.[7]

After irradiation, the samples were transferred to enrichment media and incubated for 24 hours at 98.6° F. (37° C.). Bismuth sulfite agar plates were streaked from these cultures and incubated for 48 hours at this same temperature. When present, *Salmonella* organisms appeared as typical black colonies. The number of viable organisms in the inoculated egg magma was determined by MPN counts (most probable number of organisms) made concurrently with the irradiation procedure. Although it was recognized that other tests are necessary for the absolute identification of *Salmonella*, this shortened method was considered adequate to indicate positive results, especially as the samples were inoculated at such levels as to contain several million *Salmonella* per ml. of egg mixture.

In one case the pH of the egg magma was adjusted to 5.5 before inoculation. In all other cases the pH was that normal to the eggs.

For determination of the organoleptic qualities, a quantity of egg magma was subjected to the cathode ray treatment found necessary to destroy *Salmonella*. These irradiated eggs were scrambled in small units and compared with scrambled non-irradiated eggs in a triangle-type test. A similar flavor analysis was also made on whole egg magma that had been irradiated at the sterilizing level of 300,000 rep, spray-dried, and rehydrated for testing. This spray-dried irradiated egg magma was compared with samples that were spray-dried without prior irradiation.

For determination of the baking quality, sponge cakes were made from egg magma that had been subjected to cathode ray irradiation at a level necessary for destruction of *Salmonella*. These cakes were compared with sponge cakes made from non-irradiated eggs. The cakes were baked in triplicate and judged by volume, color, and organoleptic qualities.

Further details of the method and procedure used in the various determinations are given in the Appendix.

RESULTS AND DISCUSSION

Destruction of Salmonella. The data in Tables 1, 2, and 3 show that slightly higher irradiation doses were necessary to destroy *Salmonella* in egg magma inoculated with cultures incubated 48 hours than were necessary in the case of egg magma inoculated with cultures incubated only 24 hours. This finding is in agreement with the observations of other investigators concerning the effect of culture age on resistance of bacteria to unfavorable environmental conditions. Therefore, the conclusions regarding the level of irradiation required for complete destruction of the *Salmonella* will be based on results obtained with the 48-hour inoculum.

A comparison of the data in Table 1, 2, and 3 shows that *S. senftenberg* was destroyed at 125,000 rep whereas *S. paratyphi* and *S. typhimurium* were not destroyed until an irradiation level of 300,000 rep was attained. This finding is of particular interest because, as pointed out in the literature review, strains of *S. senftenberg* are especially heat-resistant and have been shown to be more resistant to destruction by heat than is *S. typhimurium*. The culture of *S. senftenberg* used in the irradiation tests was obtained from the Quartermaster Food and Container Institute, Chicago, Ill., and was a subculture of a type of *S. senftenberg 775 W* known to show a high degree of heat resistance.

The results, therefore, indicate that it is necessary to irradiate at levels of 300,000 rep to assure destruction of *Salmonella* in whole egg magma. It is possible that lower doses would be destructive to *Salmonella* in egg magma at lower levels of contamination. However, the high levels of contamination (several million per ml.) were used to simulate the worst conditions that might be expected.

Certain investigators[8] have found that the resistance of some *Salmonella* organisms to heat is greatly increased when the organisms are suspended in acidified egg magma. This observation is of practical importance because of the acidification step in the production of so-called "stabilized spray-dried whole eggs." Table 3 shows that the level of cathode ray treatment required for destruction of *Salmonella* is not greatly affected by acidification of the egg magma.

Flavor analysis. Table 4 shows the results of flavor analyses on scrambled egg dishes prepared from eggs

[7] The rep, in general terms, has been defined by radiobiologists as the density of energy absorbed by one gram of ordinary tissue; more specifically, the rep is equivalent to 93 ergs of energy density absorbed by one gram of ordinary tissue.

[8] Private communication from Dr. M. M. Rayman of the Quartermaster Food and Container Institute for the Armed Forces, Chicago, Ill.

TABLE 1

Effect of cathode rays on liquid whole egg inoculated with Salmonella paratyphi

Cathode ray dose (rep)	Number of positive tubes (out of 10)	
	24 hour inoculum (MPN = 3,500,000)	48 hour inoculum (MPN = 2,400,000)
100,000		10
150,000		10
200,000		6
250,000		3
300,000	0	0
400,000	0	
500,000	0	

TABLE 2

Effect of cathode rays on liquid whole egg inoculated with Salmonella typhimurium

Cathode ray dose (rep)	Number of positive tubes (out of 10)		
	24 hr. inoculum		48 hour inoculum
	MPN = 9,600,000	MPN = 14,000,000	MPN = 28,000,000
100,000	10		
125,000		9	8
200,000	10	6	4
225,000		6	3
250,000		0	3
275,000		0	1
300,000	0		
400,000	0		
500,000	0		

TABLE 3

Effect of cathode rays on liquid whole eggs inoculated with Salmonella senftenberg

Cathode ray dose (rep)	Number of positive tubes (out of 10)			
	24-hr. inoculum		48 hr. inoculum	
	MPN = 2,400,000 pH = normal	MPN = 6,400,000 pH = normal	MPN = 16,000,000 pH = 5.5	MPN = 8,500,000 pH = normal
50,000				10
75,000				8
100,000		0	9	3
125,000				0
150,000				0
200,000		0	0	
300,000	0	0	0	
400,000	0	0	0	
500,000	0	0	0	

TABLE 4

Flavor analysis of irradiated whole egg melange

(12 triangle tests in each experiment)
(Control vs. irradiated at 300,000 rep)

Expt. No.	Judgments	Preferences based on correct responses
No. 1 Fresh eggs	7 correct 5 incorrect Not significant	6 preferred control 1 no preference (5 wrong)
No. 2 Fresh eggs	10 correct 2 incorrect Significant at 0.1% level	10 preferred control 1 no preference (1 wrong)
No. 3 Dehydrated eggs	8 correct 4 incorrect Significant at 5% level	5 preferred control 2 preferred irradiated 1 did not like either (4 wrong)

irradiated at 300,000 rep. In Experiments 1 and 2 (triangle tests), fresh whole egg magma was compared with freshly irradiated whole egg magma. In Experiment 1, 7 of the 12 judges correctly identified the two materials. If the null hypothesis that the 2 samples are the same in flavor is tested by the chi square test, the hypothesis is not rejected because the chi square value (3.38) is not significant at the 5% level. In Experiment 2, 10 of the 12 judges correctly identified the 2 materials. In this case, the hypothesis that the 2 samples are the same in flavor is rejected. The chi square value (13.5) is significant at the 0.1% level.

If the judgments of the first experiment were due to the inexperience of the judges, they could be eliminated as practice judgments. If, to be conservative, these judgments are combined with those of the second experiment (17 of 24 judgments correct), the result is still significant at the 0.1% level (chi square = 30.38). This leads to the conclusion that eggs irradiated at 300,000 rep acquire a flavor that can be differentiated from that of non-irradiated eggs. Analysis of the preference judgments also indicates that the non-irradiated eggs were preferred to the irradiated eggs.

In the experiment in which spray-dried eggs, non-irradiated and irradiated, were compared, 8 of the 12 judgments were correct. The chi square test, when applied to this result, indicates that the hypothesis that the flavor in both samples is the same can be rejected. The chi square value (6.0) is significant at the 5% level. Analysis of the preference judgments indicates that, although a difference in samples could be detected, the non-irradiated sample was not preferred over the irradiated sample. The chi square value (1.12) is not significant at the 5% level.

Baking test. The baking of sponge cakes was chosen as a test procedure because the baking performance of such cakes is a highly sensitive index to destructive changes in the quality of egg protein as well as to changes in the colloidal state of the emulsion of yolk lipid material. Table 5 shows that the volumes of sponge cakes prepared from egg magma irradiated at 300,000 rep were about the same as those of cakes made from non-irradiated or control eggs. The slight difference in average loaf volume, based on the volumes of only 3 samples, is not considered significant.

A slightly lighter crumb color of the cakes made from the irradiated eggs was noted but only when they were compared with the control cakes. The change was considered too slight to be objectionable.

The flavor analysis of these sponge cakes was considered only as an exploratory experiment and, therefore, the cakes were not subjected to a statistically valid taste test. However, it was the opinion of a series of inexperienced tasters (8 laboratory personnel) that any difference between the cakes from the irradiated eggs and those from the control was slight, and there was no consistency of preference. This comparison was based on taste, odor, and texture. As these cakes contained no flavoring agent, the comparison was probably more critical than would be the case in a consumer acceptance test.

TABLE 5

Results of baking test on liquid whole egg magma irradiated at 300,000 rep

Control	Irradiated
Loaf Volume (cc.):	
410	442
450	415
415	440
Avg. 415	Avg. 432

Color:
Irradiated slightly lighter than control in crumb color

Texture and Organoleptic Qualities:
Cakes from irradiated and control samples not differentiated

CONCLUSIONS

1. A cathode ray dose of 300,000 rep was necessary to destroy some *Salmonella* species (*S. paratyphi* and *S. typhimurium*) when added to whole egg magma to provide concentrations of several million per ml.

2. A cathode ray dose of 125,000 rep destroyed *S. senftenberg* when present in egg magma at levels of several million per ml.

3. The acidification of egg magma to pH 5.5 had little effect on the cathode ray dose required for destruction of *Salmonella*.

4. *Salmonella* organisms from a 48-hour culture showed slightly greater resistance to destruction by cathode ray irradiation than did organisms from a 24-hour culture.

5. A noticeable off-flavor is detectable in scrambled egg dishes prepared directly from egg magma irradiated at a level of 300,000 rep. Spray-drying of similar irradiated eggs minimized differences between irradiated and non-irradiated eggs to a considerable degree. There was no significant preference for scrambled egg dishes prepared either from eggs irradiated at 300,000 rep and spray-dried or eggs spray-dried without irradiation.

6. Sponge cakes made from eggs irradiated at 300,000 rep were comparable to cakes made from non-irradiated samples, with respect to volume, texture, and organoleptic qualities.

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APPENDIX

Methods and Procedure

DESTRUCTION OF SALMONELLA BY CATHODE RAY IRRADIATION

Preparation of inoculated blended whole egg samples. One dozen fresh eggs were broken into the top of a previously sterilized metal blendor. The cover was placed on the blendor top, and the eggs were mixed for *2* minutes. A 6-ml. portion of a *24*- or 48-hour culture of *S. senftenberg* 775 W, *S. paratyphi* ATCC 9444, or *S. typhimurium* ATCC 9148 was added, and the mixture was again blended for one minute. The blended product was poured into a large, previously sterilized beaker and allowed to settle for 5 minutes to reduce the foam volume, after which portions of about 7 ml. each were poured into 10- to 50-ml. sterile beakers. These were then set into a rack and covered with sterile aluminum foil.

Irradiation levels. Samples prepared as indicated were irradiated with high-voltage cathode rays, by means of a Van de Graaff electrostatic generator operated at a potential of *3* megavolts. This limits the effective penetration to about 1 cm. in materials of unit density. In determining irradiation levels necessary to destroy *Salmonella* with high-voltage cathode rays, preliminary tests were made in which doses between 100,000 and 500,000 rep were applied in steps of 100,000 rep. After the preliminary tests had been completed, doses between 100,000 and 300,000 rep in steps of 25,000 or 50,000 rep were used to determine the level necessary for destruction of these organisms.

Bacteriological examination of non-irradiated samples. Series of 5 tubes of tryptose broth were inoculated with preparations of the non-irradiated contaminated egg mixture. Each of 5 tubes of any series was inoculated with a portion of 1 ml. of the inoculated mixed eggs or with 1 ml. of a dilution therefrom. The inoculated tubes were incubated for *24* hours at 98.6° F. (37° C.), after which *2* loopfuls from each tube were transferred to solidified bismuth sulfite agar in a petri dish. This inoculum was spread over the surface of the agar with a sterilized, bent-glass rod, after which the same contaminated rod was used to streak a second plate of bismuth sulfite agar. Examination of the streaked plates for typical *Salmonella* colonies was made after incubation at 98.6° F. (37° C.) for *24* and 48 hours.

Bacteriological examination of irradiated samples. Ten inoculated samples were used for each test at any irradiation level. After irradiation, the total volume of inoculated egg mixture in each beaker (about 7 ml.) was poured into a tube of tryptose broth. Broth cultures were incubated at 98.6° F. (37° C.) for *24* hours, after which *2* loopfuls of culture were removed and streaked on bismuth sulfite agar as was done with non-irradiated samples. Plate cultures were examined for typical colonies of *Salmonella* after incubation at 98.6° F. (37° C.) for *24* and 48 hours.

Irradiation for purposes of spray drying and for flavor analyses. Irradiation for purposes of drying and flavor testing required that liquid whole eggs be treated in volumes of 1 to *2* liters. Although such materials could be irradiated through a piping system, it was felt that the best approach for the present scale of operations was to place the liquid egg in a series of flat containers moving on a belt under the cathode ray source. A melange of whole eggs was prepared from fresh shell eggs in a Waring Blendor. The liquid egg was placed in quarter, flat sardine cans (quarter-pound oil cans) in quantities of 50 ml. to provide a depth of product of less than 1 cm. The cans were sealed and then irradiated on a moving belt, which carried them under the source of electron emanations. As investigations to determine bacterial destruction immediately after irradiation had indicated that no viable *Salmonella* organisms were present when a dose of 300,000 rep was given, the irradiated samples used for flavor analyses were subjected to this level of cathode ray irradiation. After irradiation, the contents of a number of cans were pooled and blended by stirring. A part of this mixture was used to prepare scrambled eggs for flavor tests. The remainder was spray-dried, then reconstituted, and used to prepare scrambled eggs for flavor tests after a minimum of time had elapsed.

Spray drying. Eight dozen fresh eggs were separated from the shell and blended, one dozen at a time. The melange was filtered through cheese cloth to remove the chalazae. This resulted in about 4800 ml. of liquid, which was mixed and divided into two portions, the control and the portion that was to be irradiated. The samples were dried in a small spray drier designed and built in the Department of Food Technology at the Massachusetts Institute of Technology. Both control and irradiated eggs were dried with an inlet temperature of 240° F. (115.6° C.) and an outlet temperature of 150° F. (65.6° C.)—dry bulb temperatures. In no case was the material adhering to the sides of the drier included. The irradiated sample, before being dried, was stored in a refrigerator at 38° F. (3.3° C.). Meanwhile the control sample was dried, and the drier was washed thereafter, a period of *2* hours. Both dried samples were stored at 38° F. (3.3° C.) until used in the flavor test, which took place the day after drying.

Flavor analysis. A triangle-type test with 12 judges on the panel was used to determine whether the irradiated sample could be distinguished from the control and, if so, whether there was a favorable or unfavorable change in flavor. Each judge was provided with *3* samples, consisting of *2* controls and one irradiated sample or *2* irradiated samples and one control, and was asked to tell which samples were alike (as a check on whether a detectable flavor change had resulted from the irradiation) and then state his preference. The eggs for the test were scrambled. Approximately 600 ml. of liquid egg mix is required for 12 judges. Three dozen eggs yielded 1800 ml. of liquid, which was ample for both the control and the irradiated samples. The eggs were blended, and the mix was divided into *2* equal portions. The control portion was kept at room temperature until the irradiated portion was ready. Then both were placed in the refrigerator until afternoon, when the taste tests were performed (*2* hours later). The dehydrated eggs were reconstituted in accordance with the procedure of Pearce and Thistle,* namely, a *24*-gram portion of egg powder was com-

*Pearce, J. A., and Thistle, M. W., 1942. Fluorescence as a measurement of quality in dried whole egg powder. *Canad. J. Research*, **20**, 276-282.

bined with 100 ml. of distilled water. Increasing this formula by 6 gave sufficient liquid egg mix for each test. The blended egg mix was measured in 25-ml. portions into glass beakers and cooked on a water bath at a temperature of approximately 194° F. (90° C.), with constant stirring until it was coagulated. The time required was approximately 3½ minutes. Eggs were cooked in a battery of 6, so that enough samples for 2 tests were available at each cooking period. The eggs were served to the judges immediately after being cooked. Salt was not used.

Baking test. The contents of 9 fresh eggs were mixed in a Waring Blendor and divided into two portions. Half of the blended melange was placed in washed, quarter sardine cans in 50-ml. amounts. Thus the depth of egg in the can was slightly less than 1 cm. The cans were irradiated at 300,000 rep with the covers off. After irradiation the contents of the cans were pooled and stored in a covered jar until used in the baking test, within an hour after irradiation. Small sponge cakes were made in triplicate, with separate portions of liquid egg, both irradiated and control. The ingredients used were:

liquid egg	50 gm.
granulated sucrose	40 gm.
cake flour (non-self-rising)	40 gm.

Letter From Vienna

FELLOW FOOD TECHNOLOGISTS AND SCIENTISTS:

Scientific, analytical and food chemists of the three German-speaking countries — Germany, Switzerland, and Austria — held their annual meeting at Innsbruck, Tyrol, March 30 to April 1, 1953. More than 550 chemists attended and heard many interesting reports on various subjects relating to the chemistry of foods and related topics. Following are briefs from some of more than 60 reports presented at the meetings. It is hoped that they will give an impression at least of the nature and scope of the scientific program.

Dr. Brockmann, Gottingen, has isolated quite a number of antibiotics from *Actinomycetes*. *Streptomyces chrysomallus* was shown to give the red antibiotic *Actinomycin C*—which is similar to Waksman's *Actinomycin A* and Dagliesh and Todd's *Actinomycin B*. *Picromycin*, another new antibiotic, was isolated from a new *Actinomyces* not yet identified and *Rhodomycin*, a reddish substance, was extracted from an *Actinomyces* growing on soil. These substances have strong antibiotic properties and are now being tested for clinical purposes. They have proved to be effective, even against cancer, in preliminary observations.

Dr. Kratky, Graz, discussed the shape and size of colloid particles; the X-ray small angle method was used to obtain the data presented.

O. Isler and K. Doebel, Basel, reported some new synthetic methods for the vitamin K group. The known synthesis of vitamin K_1 and of dihydrovitamin-K_1-diacetate from 2-methyl-naphtholhydraquinone was improved by using borom-tri-fluoride-etherate as the condensing medium. Synthesis was executed with phytol, phytylacetate, phytylformiate, phytylchlororacetate, phytylmethylether, isophytol—synthetic and optically active—and isophytylacetate. Synthetic isophytol gives a vitamin K_1 with a racemic phytyl side chain—which is only slightly different from the natural vitamin K_1 with the optically active side chain. Both substances prove to have the same UV-spectra and the same biological activities.

C. G. Engster, Zurich, has synthesized several carotenoids by partial reduction of the acetylene bonds.

H. Liers, Munich, reported his recent investigations on melanoidins, the reaction products of proteins with carbohydrates. Using the glucose-glycine standard of Enders and Theis he has sought to synthesize melanoidin-like substances by high pressure (500 atm.); he has laid stress on the pH values of the products. Unfortunately, this promising work has been interrupted by the death of his research associate.

A. Lindner, Munich, discussed the international aspects of wine analysis and wine judging. He reports it to be rather difficult even to bring European methods into conformity; every country prescribes its own analytical methods in its own terms. Several conferences have been held but to date no final decisions have been made. Most difficult of all to bring into conformity are the dessert wines, owing to the special formulae being used by different countries. It was contended that all of these wines should be classified in five categories according to their sugar content.

K. Möhler, Munich, reported his investigations on the properties of polymer phosphates in animal proteins. The soaking effect was studied by means of estimating sedimentation; it was found that this depends very much on the pH value. Metaphosphates in small concentrations promote the coagulation of meat proteins, it was reported.

If my fellow research workers are interested, I shall be pleased to report again on events in European food chemistry.

DIPL. ING. OTTO RIEDL
Felix Mottlstra. 50
Vienna XIX, Austria

28 May 1953

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Abstracts

(Continued from page 18 preceding technical papers)

Storage of fresh shrimp in ice.
Refrig. Res. Foundn. Info. Bull., No. 53, 2, February 15, 1953.

After 4 to 6 days of ice storage, the shrimp lose their characteristically sweet taste. Some phys. changes have been under observation which take place after about 6 days, and it seems that enzymes present in the shrimp may be at work, causing a reduction of flavor quality well in advance of bacteriol. action.

PACKAGING

Waterproof corrugated fibreboard containers.
Packaging, 119, 21, January, 1953.

Normally waterproof, and retaining a great part of their strength after prolonged immersion in water, corrugated fibreboard containers made from "wet-proofed" board represent an important development.

PHYSICAL RESEARCH

Radioactive monolayers: A new approach to surface research.
Beischer, D. E. *J. Phys. Chem., 57,* 134-8 (1953).

The study uses monomol. layers prepd. by the method of Langmuir and Blodgett to bring a limited supply of a reagent in the form of a homogeneous monolayer of carbon-14- tagged stearic acid on the surface of different materials. The system is heated to a degree where chem. reaction of the coating material with the topmost layer of the surface takes place. The excess of the monolayer reagent is then removed and the distribution of the reaction product visualized in a radio-autograph of the surface. The extreme sensitivity of this method allows localization and measurement of small differences in the chem. activity of a surface.

Photochemistry of proteins. XVII. Inactivation of enzymes with ultraviolet light and photolysis of the peptide bond.
McLaren, A. D., Gentile, D., Kirk, Jr., D. C., and Levin, N. A. *J. Polymer Sci., 10,* 333-44 (1953).

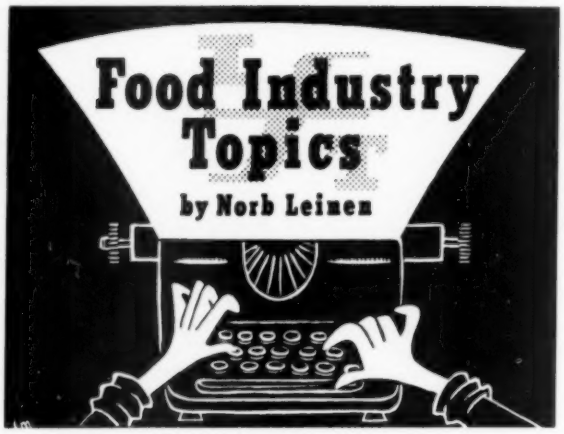
Ribonuclease and carboxypeptidase are inactivated by ultraviolet light (2537A.) with quantum yields of 0.03 and 0.001-0.005 resp. The quantum yields for low mol. wt. proteins are of the order of 0.03 and are higher than those for splitting peptide bonds in typical peptides (0.004-0.0004 or less). It is postulated that the primary process of inactivation involves modification of aromatic residues in proteins. A possible reason for the inverse relationship between quantum yields and mol. wts. of enzymes and proteins is discussed.

True and apparent activation energies of enzymic reactions.
Gibson, K. D. *Biochim. et Biophys. Acta, 10,* 221-9 (1953).

From a consideration of the Michaelis equation and the Arrhenius equation, it is shown that it is necessary to distinguish two quantities in enzymic activation: a) the heat of formation of the enzyme-substrate complex, and b) the energy of activation of this complex. An equation is derived connecting these two quantities with the activation energy observed at any concn. of substrate. Some activation energies recorded in the literature were examd. in the light of this equation. It was found that, with a few notable exceptions, the values recorded for activation energies of enzymic reactions are open to criticism on the grounds that they represent a combination of the two quantities above, and hence by themselves have no phys. significance.

On the mechanism of inhibition of urease.
Kistriakowsky, G. B., and Shaw, W. H. R. *J. Am. Chem. Soc., 75,* 866-71 (1953).

The inhibition of urease by three urea analogs, sulfamide, acetamide and thiourea, was investigated. The first compd. has no observable effect on the enzyme. The second inhibits it very slightly. Only the inhibition by thiourea was strong enough for a quant. study. The results show this reaction to be instantaneous and reversible.



One brief preliminary note. Because last month's issue was replete with news of the June Meeting, certain deletions of material were considered necessary by The Printer. Unfortunately, as often happens in cutting national budgets or news columns, a quantity of muscle was pared away along with the fat.

Some news items concerning what's astir in Government, university, and other institutional laboratories were also casualties. As this column grows in age and dignity, it becomes necessary to accent the serious, soften the approach, and widen the horizons. As a start in this direction, we open with items about two cousinly organizations—the Canadian and the U. S. Departments of Agriculture.

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Our good neighbor to the North sends in a series of five eight-page brochures, some in two colors, explaining the work and facilities of several field laboratories of Science Service, Canada Department of Agriculture. Interestingly written and well-illustrated, the brochures cover the Science Service Laboratories at Harrow, Ontario (Plant Diseases, Fruit Insects); London, Ontario (Bacteriology, Chemistry, Entomology, Fumigation Studies, Plant Pathology, Plant Physiology); Kentville, Nova Scotia (Chemistry, Fruit Insects, Field Crop Insects, Plant Diseases); Ste. Anne de la Pocatiere, Quebec (Plant Diseases, Field Crop Insects, Seed Potato Certification Office); and the Laboratory of Entomology, Chatham, Ontario (Field Crop Insect Investigations). Each booklet carries a complete listing of the offices and laboratories in the Science Service. To request this literature, write Dr. K. W. Neatby, Director, Science Service, Canada Department of Agriculture, Science Service Bldg., Carling Avenue, Ottawa.

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Our own U. S. Department of Agriculture is not found wanting in this month's mail. From the Southern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry, located at 2100 Robert E. Lee Blvd., New Orleans 19, La., comes word of a new preservation-prediction chart for yeast spoilage in sweet cucumber pickles, and of two new antioxidants that are close to the test-completion stage. The yeast spoilage chart shows the exact proportions of sugar and vinegar that need to be added during the manufacture of sweet cucumber pickles so that they will keep safely. Its use by processing plants should aid in standardizing sweetening formulas, in reducing spoilage, and in saving sugar. The two new antioxidants, *alpha-* and *beta*-conidendrol—polyphenolic compounds derived from conidendrin, a substance occurring in many coniferous woods—have been compared with accepted stabilizers as inhibitors of oxidative rancidity in cottonseed and peanut oils, in lard, and in fat-

(Continued on page 24)

For Sparkling Fruit Juices... clarify with

PECTINOL

Clear, sparkling fruit juices have eye appeal—are the ones that customers pick from store shelves. That's why apple juice all over the country is clarified with PECTINOL. That's why more and more grape juice is being given sales appeal by PECTINOL treatment.

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Food Industry Topics

(Continued from page 22)

containing candies, as stabilizers of synthetic rubber against aging and hardening, and as inhibitors of polymerization of certain vinyl-type monomers. Investigators found that the conidendrols performed as well as or better than a number of accepted stabilizers, including some marketed at higher prices than would be the conidenrols. Because of plentiful supply, the derivatives would be of interest as potential replacements or supplements for stabilizers obtained from coal tar (benzene or napthalene) if these became scarce. However, before the use stage is reached, toxicity studies now underway at the Western Regional Research Laboratory, USDA, must be completed.

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Dodge & Olcott, Inc., never addicted to idleness, opens its monthly barrage with a new brochure that exudes Gallic good taste and charm. Containing 12 pages of formulas and directions for preparing and flavoring salad dressings and sauces, and intended for manufacturing and professional use only, the Salad Dressing Brochure is divided into three sections: French Dressings, Salad Dressings, and Mayonnaise. Each section opens with a copy of the Federal Standards for that particular product. In addition to the formulas and directions, special mixing hints have been included, and the folder carries a third cut for easy filing and reference. This brochure is the fifth in a series of flavor folders prepared by D&O for the convenience of manufacturers, and is available on request to Dept. SAL, Dodge & Olcott, Inc., 180 Varick St., New York 14, N. Y.

Not to be outdone, the D&O Perfume Laboratories have come up with a *new line of perfume bases designed specifically for scenting liquid and powder detergents.* Christened DETEROMES, the new odorants have been designed to withstand the unusually high temperatures of manufacturing processes and to mask even the tenacious odor of the petroleum base most frequently used in synthetic detergents. Available in many different fragrances, DETEROMES should be used in the following proportions: liquid, from ⅛ to ¼ ounce per gallon; powder, from ⅛ per cent to ¼ per cent.

Two more quickies from D&O: (1) the 180 Varick Street premises, formerly called the Graybar-Varick Building, has been officially renamed the Dodge & Olcott Building in time for the company's 155th anniversary celebration; (2) De Laire, Inc., a newly established corporation, opened its New York City office at 114 E. 32nd St. The new company replaces the former De Laire Division of Dodge & Olcott, Inc., and the former association is now terminated.

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Europe's great international trade fairs are the subject of an illustrated 32-page booklet now being distributed free of charge by the European Travel Commission, representative of 21 Western European countries. Designed to acquaint U. S. businessmen with the growing importance of these fairs at which many millions of dollars worth of orders are placed annually, the booklet contains detailed descriptions of 18 of the major fairs of 1953. Also included are dates, number and types of exhibitors, exhibition facilities, attractions of the cities in which the fairs are held, and addresses of representatives in North and South America. For a free copy write European Travel Commission, News Bureau, 295 Madison Ave., New York 17, N. Y.

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Lovers of smoked, pickled ripe olives (and who isn't?) may soon find their favorite delicacy on grocery store shelves. Food technologist and IFT member Prof. Wm. V. Cruess of the University of California College of Agriculture revealed that a taste panel enthused over olives smoked by a process that he has perfected. (Make mine Manhattan.)

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A well-turned-out brochure tells the story of the *industrial sanitation services* provided by Orkin Institute of Industrial Sanitation, 713 Peachtree Street, Atlanta, Ga. Activities of the Institute range from periodic inspection auditing the status of compliance with food sanitation requirements, to advice on plant design as it is affected by sanitary considerations. The organization also can perform micro-analytical services, and can set up a sanitation school for persons employed in processing or serving foods. The five-point consultative program outlined by the Institute entails analysis, planning, inspection, quality control, and employee training. For further details write IFT member Mr. Keith A. Fitch, executive director, at the above address.

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Mr. Herman L. Fellton, for the past seven years Orkin Exterminating Company vice president in charge of technical operations and also vice president of the Orkin Institute of Industrial Sanitation, is no longer with that organization and has gone into business for himself as a sanitary engineer consultant at 15 Peachtree Place, N. W., Atlanta, Ga. Mr. Fellton, active in sanitation work since 1934 and a member of many trade and professional organizations, will be available for consultation on food plant and industrial sanitation, insect and rodent control, insecticides and rodenticides, and other sanitary engineering and entomological matters.

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The Morton Packing Co., Louisville, Ky., largest packer of frozen meat pies in the country, announces that a substantial interest in the company has been purchased by J. H. Whitney & Co., New York City private investment bankers. According to Mr. George E. Egger, president of the Morton Co., the investment house has made other substantial investments in the food field, including the Minute Maid Corporation, and made the purchase of Morton stock because of the company's excellent prospects for continuing its rapid expansion and leadership in its field. Morton products include Morton's Chicken Pot Pie, Beef Pot Pie, and Turkey Pot Pie.

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Sylvania Division, American Viscose Corporation, has just published a revision of its "Characteristics and

(Continued on page 26)

GUARD the critical point where milk enters the dairy to be processed. Here, samples from each farm are inspected with the aid of Spencer Microscopes and Colony Counters so that no single batch can contaminate the entire output.

Be sure your laboratory has modern, efficient equipment to match the high standards set elsewhere in your dairy. New Spencer Microscopes offer many advantages to help your technicians do a thorough job—improved optical performance, convenient adjustments, newly designed attached light sources if desired. The new Spencer Darkfield Colony Counter has improved illumination that increases counting accuracy and reduces operating fatigue.

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Food Industry Topics

(Continued from page 24)

Uses" chart which lists all standard types and gauges of Sylvania Cellophane, and briefly describes recommended uses for each. Most important change in the new chart is the broadening of Sylvania MS-3 for general bag use. Because of its good moistureproofness, excellent stability, tenacious heat-seal, and outstanding performance on high-speed machines, it is now suggested for a wide variety of products from chocolates to potato chips. Sylvania MS-2, formerly recommended for fabrication of bags with adhesives, is now recommended primarily for direct and twist wraps, used for such items as textiles, spaghetti, and hard candies. Among the non-moistureproof "P" types, the line has been extended to include a special type (P-3) for use in tropical climates. The new leaflet, code dated 2198 1-53 may be obtained by contacting any Sylvania district sales office or writing the Market Development Dept., Sylvania Division, American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

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The role of Peracetic Acid, *a new bactericide-fungicide*, in modern food plant sanitary practice is the subject of two bulletins available to readers from the Buffalo Electro-Chemical Company, Inc., Station B, Buffalo 7, N. Y. Bulletin No. 15, "Peracetic Acid—A New Bactericide-Fungicide," describes general and bactericidal properties of peracetic acid, its use as a germicidal wash for fruits and vegetables, for reduction of fruit fly annoyance, equipment sanitizing, enzyme inactivation, and suggested evaluation procedure for peracetic acid washes. Bulletin No. 15A, "The Application of Peracetic Acid Germicidal Washes to Mold Control of Tomatoes," describes controlled pilot scale and commercial scale treatment of tomatoes with peracetic acid germicidal washes. Copies of the bulletins are available free of charge.

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The accent in the future will be on making larger packages of Ac'cent available to consumers through regular chain and grocery outlets. This was announced by Amino Products Division of International Minerals & Chemical Corp., Chicago, in connection with the appointment of Mr. Thomas W. Leary Jr. as assistant to the national retail sales manager for Ac'cent, Mr. Brooks Taylor. According to the company, consumer demand for larger and more economical packages of the product has been rising steadily, and is expected to increase even more sharply as a result of research that indicates its use in home freezing improves the flavor, color, and acceptability of many foods and also prolongs their quality over a longer storage period.

The company also has news of the return of Eddie Doucette, entertainer, television culinary artist, and master chef to his former affiliation as food consultant for Ac'cent. On a leave of absence from the firm during the past 14 months, Eddie has been the star of "Home Cooking," a daily Chicago TV show. The program, a newcomer to the telewaves when Eddie joined NBC, climbed to be one of the two top-rated cooking shows in Chicago in a matter of months. In his future activities for Ac'cent, he will follow the same general pattern he employed in achieving television popularity. Through a series of public appearances before womens' organizations, church groups, associations, etc., throughout Chicago and other parts of the country, he will continue to present new and simple ideas in cooking, tailored to the budget of the average homemaker, showing his audiences just how much fun cooking can be. Doucette can be contacted at the company's headquarters—20 N. Wacker Drive, Chicago 6, Ill.

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Many different materials used to combat corrosion in steam-operated vacuum ejectors are discussed in a four-page reprint of an article released by Croll-Reynolds Co., Inc., 17 John St., New York 38, N. Y. Such ejector materials as hard rubber, Haveg, Karbate, porcelain, Pyrex, stoneware, bronzes, chrome-plated cast iron, Duriron, and Hastelloy alloys A, B, and C are covered as well as the company's experience with such materials as illium, tantallum, beryllium copper, and higher stainless steels in the metal field, Teflon, Synthane, and other plastic materials, plastics which use Fiberglas as a filler, and carbon. Since steam-operated vacuum ejectors are more vulnerable to corrosion than other items of plant equipment, the article is of interest in fields where steam-jet equipment has been applied to deaerators, evaporators, deodorizers, crystallizers, vacuum refrigerating units, etc.

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As part of its expanding customer service program, Seaplant Chemical Corp., New Bedford, Mass., announces the appointment of Mr. Melvin Mickevic as sales engineer. Mr. Mickevic was formerly a district representative for J. W. Greer Co., with whom he won industrial recognition in the food field for a series of papers and talks on crystalline properties and physical testing of fats.

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Soups on! But with a difference. The California soup makers, Andersen's Foods, Inc., Santa Barbara, have announced a brand *new line of low sodium, low calorie canned soups* . . . reportedly the very first top quality dietetic soups to be marketed by a national food processor. Three numbers—Split Pea, Potato, and Tomato Vegetable—all are prepared from original Juliette Andersen recipes. A special salt substitute is used to assure top flavor. According to Robert T. "Pea Soup" Andersen, the new dietetic line is proving a strong seller, with heavy initial orders and brisk turnover. Mr. Andersen pointed out that one reason for the wide acceptance of the dietetic soups is that they do not compete with any other items on the shelf, thus providing the grocer with new profits where none previously existed.

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A modern myth has been dispelled by scientists working in the laboratories of Chas. Pfizer & Co., Inc. In the studies, chickens fed rations containing up to 1000 grams of terramycin and penicillin per ton of feed laid eggs without a detectable trace of the antibiotics. (The 1000-gram level contrasts with the two to five grams of penicillin and up to ten grams of terramycin per ton of feed when used nutritionally. Therapeutic levels run up to 100 grams per ton of feed.) The researchers' re-

(Continued on page 28)

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Food Industry Topics

(Continued from page 26)

port is a partial answer to the question of whether animal products pass on to the consumer antibiotics used in feeds for growth stimulation and for therapeutic purposes.

Also from Pfizer comes news of a *new experimental farm*, located near Terre Haute, Ind., which combines animal nutrition and veterinary medicine into a single research unit. Also on the 700-acre tract, are laboratories and offices and the Vigo plant where Pfizer manufactures its line of agricultural products. In addition to tests on feeds containing terramycin, penicillin, and other antibiotics, nutritional studies are underway on the animal requirements of vitamin E, vitamin K, vitamin B12, and other vitamins as well as unidentified growth factors. Veterinary medical studies include the treatment of chickens for air sac infection, mastitis, scours in calves and pigs, and the effects of antibiotics on the rumen of cows. The farm research team is headed by Herbert G. Luther, Director of Agricultural Development, and Dr. James McGinnis, noted poultry nutritionist.

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Two sales department personnel re-assignments involving IFT members are announced by Mr. B. F. Bowman, vice president in charge of sales and product development, the Huron Milling Co., New York City. Mr. L. S. Rolf has been named manager of the company's Mid-West Division, succeeding Mr. G. H. Freeman who has been tranferred to New York headquarters as director of Sales Specialty Products. Huron also sends news that Mr. Jeff Pfaff who formerly serviced company accounts in Indiana and parts of Illinois, Kentucky, and Missouri, is now a member of the Chicago sales office staff, handling accounts in the Chicago-Milwaukee area.

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Mr. Chas. P. Clancy has been appointed sales representative in the Midwest territory for Huron, it was also announced by Mr. Bowman. Joining the staff of Huron's newly appointed Mid-Western Manager, L. S. Rolf, Mr. Clancy will make his headquarters in Omaha, Nebraska. According to the company, Mr. Clancy's appointment is another step in the continuing program to provide top-notch sales and service assistance to Huron customers in this important area.

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Kraft Foods Company, Chicago, also sends in a personnel note. Mr. Charles W. Kaufman, vice president and director of research, has been named a director of the company. According to the company's president, Mr. G. C. Pound, Mr. Kaufman's election as a director points up the importance Kraft places on research activities. The new director, an IFT member, has had broad experience in research in many branches of the food industry, having been associated with General Foods, the National Canners Assn., the National Fruit Products Company, and the wartime Quartermaster Subsistence Research Laboratory prior to his coming to Kraft in 1950.

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Here's that money your columnist was hopefully looking for (and not finding) two columns ago. Triad Laboratories, 530 34th Street, Union City, N. J., encloses a mint-fresh copper bas-relief of Abe Lincoln in its mailing citing the virtues of its butter flavor product, Butr-Bak. The product is reported to be a concentrated flavor that has captured the true flavor of real butter, but is approximately 400 times the strength of butter. The secret is apparently in the company's special process for isolating the trace quantity of essential oil that gives the unique "butter taste." The isolated ingredient is then incorporated into edible oils to make Butr-Bak. According to the manufacturer, addition of a few ounces of the product per 100 lbs. of liquid or solid shortening produces a shortening that can be promoted to the industrial consumer for the "baked-in-butter" taste in his baked goods and to the housewife and restauranteur for similar effects in their home baking and frying. The firm will be happy to forward a standard sample of Butr-Bak and the current price schedule upon request.

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A last-minute item from Honeywell, a new Industrial Controls Catalog, seemed too good to pass up this issue. A highly legible 80 pages plus covers, Catalog 8305 describes and illustrates the company's line of non-indicating electric, electronic, and pneumatic controllers for temperature, pressure, and humidity; also pneumatic and electric valves, switches, and relays. Specifications, dimension drawings, application data, and ordering information are included. The catalog is available upon written request to the address given (far) above.

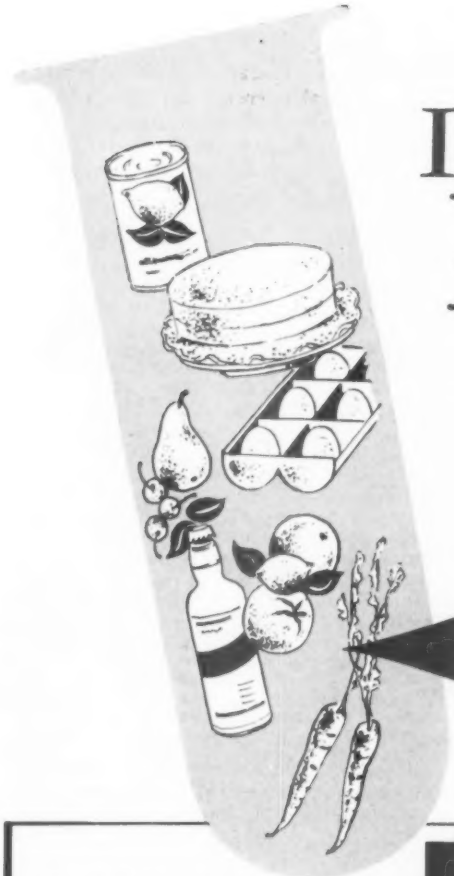
◆ ◆ ◆

The Second Edition of the Packaging Institute's Directory of Contract Packagers and Their Facilities has been published by the Packaging Institute, 342 Madison Ave., New York 17, N. Y., and is now available for price of $2.00 a copy. The 71-page book, 8½ x 11 inch size, gives full data about the packaging equipment and facilities of 81 Contract Packagers together with information about products that will be accepted or refused, and shipping facilities. A feature of this revised Second Edition of the Directory is a 15-page index by states which enables the reader to locate a possible contract packager with proper equipment in a given area without the necessity of reading the entire volume.

◆ ◆ ◆

Brown Instruments Division of Minneapolis-Honeywell Regulator Co., Wayne and Windrim Aves., Philadelphia 44, Pa., has kept its hand in the descriptive technical literature field over the past month with three new four-page specification sheets describing and illustrating Brown *ElectroniK* recording potentiometers. Specification Sheet 160 covers circular chart recorders; Specification Sheets 164 and 165 cover single and multiple record strip chart recorders. Construction and engineering details are included. To receive the new Honeywell literature, address an inquiry to Station 64 at the address given above. The company also has

(Continued on page 30)



If you can make your product better by removing troublesome

GLUCOSE or **OXYGEN**

do it now... with

DeeO (DeeGee)

another in a long series of firsts by TAKAMINE

DeeO is now being successfully applied in:

Egg Solids processing

Other suggested uses:

Canned or Packaged Foods

Bottled Beverages

DeeGee removes GLUCOSE which, in many products, reacts with proteins present (Maillard-type reaction), causing loss of flavor, browning and short shelf life.

DeeO removes OXYGEN dissolved in liquids or in contact with sealed foods preventing oxidation of flavor and color bodies.

DeeO and DeeGee are glucose oxidase-catalase enzyme systems effectively formulated to remove either glucose or oxygen from food and many industrial products.

Reactions catalyzed by DeeO (DeeGee):

$$\text{glucose} + \text{oxygen} + \text{water} \xrightarrow[\text{oxidase}]{\text{glucose-}} \text{gluconic acid} + \text{hydrogen peroxide}$$

$$\text{hydrogen peroxide} \xrightarrow{\text{catalase}} \text{water} + \text{oxygen}$$

NET REACTION:

$$\text{glucose} + \text{oxygen} \longrightarrow \text{gluconic acid}$$

(The gluconic acid formed is innocuous and actually an effective sequestering agent)

OTHER TAKAMINE ENZYMES INCLUDE

Amylases (starch splitting) and Proteinases (protein splitting) for use under varying conditions of pH and temperature

Write our Technical Service Dept. for further details and samples

TAKAMINE

TAKAMINE LABORATORY, INC., CLIFTON, NEW JERSEY

Gentlemen: We are interested in the use of DeeO (DeeGee).

Name_____ Title_____

Firm Name_____

Address_____

City_____ Zone____ State_____

Food Industry Topics

(Continued from page 28)

available the new Honeywell Instrumentation Data Sheet No. 10.5-4a describing the new concept of humidity measurement that makes possible direct humidity readings from remote locations, and a new four-page Specification Sheet 116 describing and illustrating *Pyr-O-Vane*, *Pulse Pyr-O-Vane*, and *Protect-O-Vane* automatic controllers which provide close regulation of temperature and are calibrated for use as thermocouple or radiation pyrometers.

◆ ◆ ◆

• Pascal (left), Piel (right) move up to Board of Directors, National Starch.

Two well-known figures in the starch and adhesive business, Mr. Donald D. Pascal and Mr. Herbert C. Piel, have been elected to newly created vacancies on the board of directors of National Starch Products, Inc., according to Mr. Frank Greenwall, president. Mr. Pascal, with the company since 1929 and vice president in charge of sales since 1951, is a member of the American Chemical Society and the New York Chemists' Club. He makes his home in Brooklyn, N. Y. Mr. Piel, vice president in charge of National's Indianapolis plant, has been with the company and its Indianapolis predecessor, Piel Brothers Starch Co., Inc., for 45 years. He has been closely identified with expanding uses of starch derivatives. National Starch Products, Inc., and National Adhesives (a division) is a 58 year old company engaged in the production of industrial adhesives, resins, and specialty starches. Headquarters are in New York City and offices and warehouses are maintained in principal cities throughout the country.

◆ ◆ ◆

An important chemical for medical research, thymidine, is now being made for the first time in commercial quantities by Schwarz Laboratories, Inc., Mt. Vernon, N. Y. Until the present, only a fraction of an ounce has been isolated in the laboratories of a few scientists. Lack of material has prevented wide study of how the body uses thymidine. More extensive studies will now be possible, particularly in the fields of cancer research and treatment of human anemias. The company is a pioneer in the commercial preparation of cell chemicals for research in the medical sciences, and thymidine is the one hundred and twenty-first "hard-to-get" biochemical intermediate it has developed.

◆ ◆ ◆

A new idea in a *small parts storage cabinet*—called the "Little Gem" Tiny Parts Cabinet—is now being marketed by Precision Equipment Co., 3714 Milwaukee Ave., Chicago 41, Ill. The all-steel "Little Gem," useful in office, plant, or school shop, consists of two 1½" high drawers in a rugged, one-piece welded frame. Dividers provide a total of 24 adjustable compartments within the two-drawer cabinet, and addition of extra dividers makes possible up to 56 compartments per unit. Overall size is 3¼" high x 11" deep x 11" wide. The unusual feature of the "Little Gem" is its versatility of use—either singly, stacked one above another in a rugged assembly, or as part of the Precision all-steel Standard Parts Cabinets. "Little Gems" come in a baked green finish and weigh 10 pounds. They are priced at $8.90 each, with extra dividers available at 8c each. When substituted for any two standard drawers in the purchase of a Standard Parts Cabinet, the price of each "Little Gem" unit is $4.90. Price of the Standard Parts Cabinet regularly equipped is $29.94. For further information and literature, write Precision Equipment Company at the above address.

◆ ◆ ◆

Although some of the fairs listed in the above brochure are already past history, here's news of a related event that must certainly be classified as "advance." Don't make any plans for June, 1954, other than a trip to sunshiny Spain in connection with the International Congress for Agricultural Industries to be held in Madrid. Further details will be published . . . manāna.

◆ ◆ ◆

The food, beverage, and canning industries, faced with the problem of overcoming the browning reaction and oxidative problems, will be interested in the availability of the enzyme system—glucose oxidase and catalase—in an all-soluble, powdered form. The new solid product, announced by Takamine Laboratory, Inc., Clifton, N. J., and marketed under the trade names "DeeO" and "DeeGee," supplements the more dilute, stable liquid product which Takamine placed on the market last year. Since these enzymes utilize both glucose and oxygen in the reaction which they catalyze, they may be used to remove either glucose or oxygen from products, provided sufficient quantities of oxygen or glucose, respectively, are present to balance the equation. Both the liquid and solid formulations, for which patents are pending, are stable at room temperature and without packaging under an inert gas.

◆ ◆ ◆

Canners and producers of frozen food products will be interested in a *potato-peeling machine* developed by the Pfaudler Co., Rochester, N. Y. The spuds are steam-treated under pressure in a stainless steel container and then lose their skins after a run over rubber-coated rollers.

◆ ◆ ◆

One of the most useful gifts to 1953's brides is a can opener, states American Can Company, which estimates that 788 cans of food and non-food products are used by the average U. S. family each year. The company

(Continued on page 34)

MORTON

for all your canning salt needs

Saturated high purity brine piped anywhere in your plant!

The Morton Brinemaker delivers up to 800 gals. of clear, fully saturated brine an hour, using the type of salt that is most economical or best suited for each plant. Saves labor and time—the brine can be pumped under pressure from ground floor to upper levels, or anywhere in your plant!

Morton has a salt to meet the requirements of *your* particular operation, now available from 9 strategically located plants. These specialized canning salts include *Morton 999*, a high purity salt; *Morton H. G. Granulated*, a screened high grade evaporated salt of controlled purity, quality and uniformity; *Morton K. D. Granulated*, a superior quality of evaporated salt; and *Morton Rock Salt*. A Morton Consulting Engineer will be glad to recommend the salt best suited for your needs.

Bulk Salter
For precision salting by the economical bulk method. Designed for either plant-blended mixtures or quick-dissolving Morton Salt. Buying salt in bags and dispensing accurately metered amounts into each can saves real money.

Salt Tablet Depositor
Deposits *one* tablet in *each* can at high speeds with never-fail accuracy. The tablet depositor enables the canner to get the *exact* amount of salt, or other made-to-order mixtures, into each and every can.

UP TO 800 GALLONS OF BRINE AN HOUR

—available when you want it!

MORTON SALT COMPANY
Industrial Division
Dept. CS-4, 120 S. LaSalle St.
Chicago 3, Illinois

I would like information on:

- ☐ *Morton Canning Salt*
- ☐ *The Brinemaker*
- ☐ *The Bulk Salter*
- ☐ *The Salt Tablet Depositor*

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Firm_____

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City_____ Zone_____ State_____

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Write to nearest regional secretary, if within an area covered by a regional section, or to the Executive Secretary of the Institute, for an application form and information regarding qualifications and classifications.

Staley's

your dependable source of...

Calcium Phytate — SEQUESTERING AGENTS—For stabilizing foods such as vinegar & vegetable oils. — **Phytic Acid** (40% Solution)

LECITHIN — EMULSIFIER AND STABILIZER

ZEST® (Monosodium Glutamate) — FLAVOR ENHANCER

Other quality food products made by Staley from corn and soybeans include

Corn Syrup: "Sweetose" / Intermediate Conversion / Regular

Food Starches / Soy Flours & Grits / Vegetable Oils

PRODUCTS FROM CORN Staley's AND SOYBEANS

Write for technical data and prices on those Staley Products today.

A. E. Staley Mfg. Co.

DECATUR, ILL.

A. E. STALEY MFG. CO.,
Industrial Division Dept. FT-4, Decatur, Ill.

Please send me data and prices on following products:

Name_____

Firm_____ Position_____

Address_____

City_____ Zone____ State_____

Food Industry Topics

(Continued from page 30)

ascribes the more than 500 per cent increase in use of canned products since 1901 to the convenience, quality, and economy of such products. In contrast with grandma, who spent nearly half her married life in the kitchen, today's housewife averages only two hours daily in such activities and produces comparable results (grandma, please note).

C. A. Wood
Vice-Pres. for Wm. J. Stange Co.

Mr. C. A. (Tubby) Wood, IFT member, was recently elected vice president in charge of sales for the Wm. J. Stange Company, according to Mr. Wm. B. Durling, president. Mr. Wood, who has been associated with the food processing industry for 25 years, had been company sales manager since 1950, and prior to that, manager of the Stange Manufacturing Branch in Oakland, California. He is also a vice president of the Canadian subsidiary, Stange-Pemberton, Ltd., Toronto. In assuming his new duties, Mr. Wood will be responsible for sales of all products manufactured by Stange, including C. O. S. (Cream of Spice) Seasonings, Peacock Brand Certified Food Color, and N. D. G. A. Antioxidant.

Dynel Windsor Felt, *a new type of chemically resistant, fiber-bonded filter fabric*, has just been introduced by the American Felt Company. The new Dynel material, constructed with multiply carded construction for a highly uniform fiber distribution, was developed as a superior filter mat for use in filter press or vacuum filter applications for highly efficient cake formation or clarity of filtrate. Typical filtration uses are for dyestuff manufacture, clarifying of electroplating solutions, production of yeast, chemicals, and food products. The new material is the latest addition to the range of fiber bonded Windsor Felts which were pioneered in 1937 by the American Felt Company. The company's Engineering and Research Division and sales representatives are prepared to work closely with potential users of the new filter fabric to determine suitability for specific filtration problems. For available data as to chemical and physical properties of Dynel Filter Felt, write American Felt Company, Engineering and Research Division, Glenville, Connecticut.

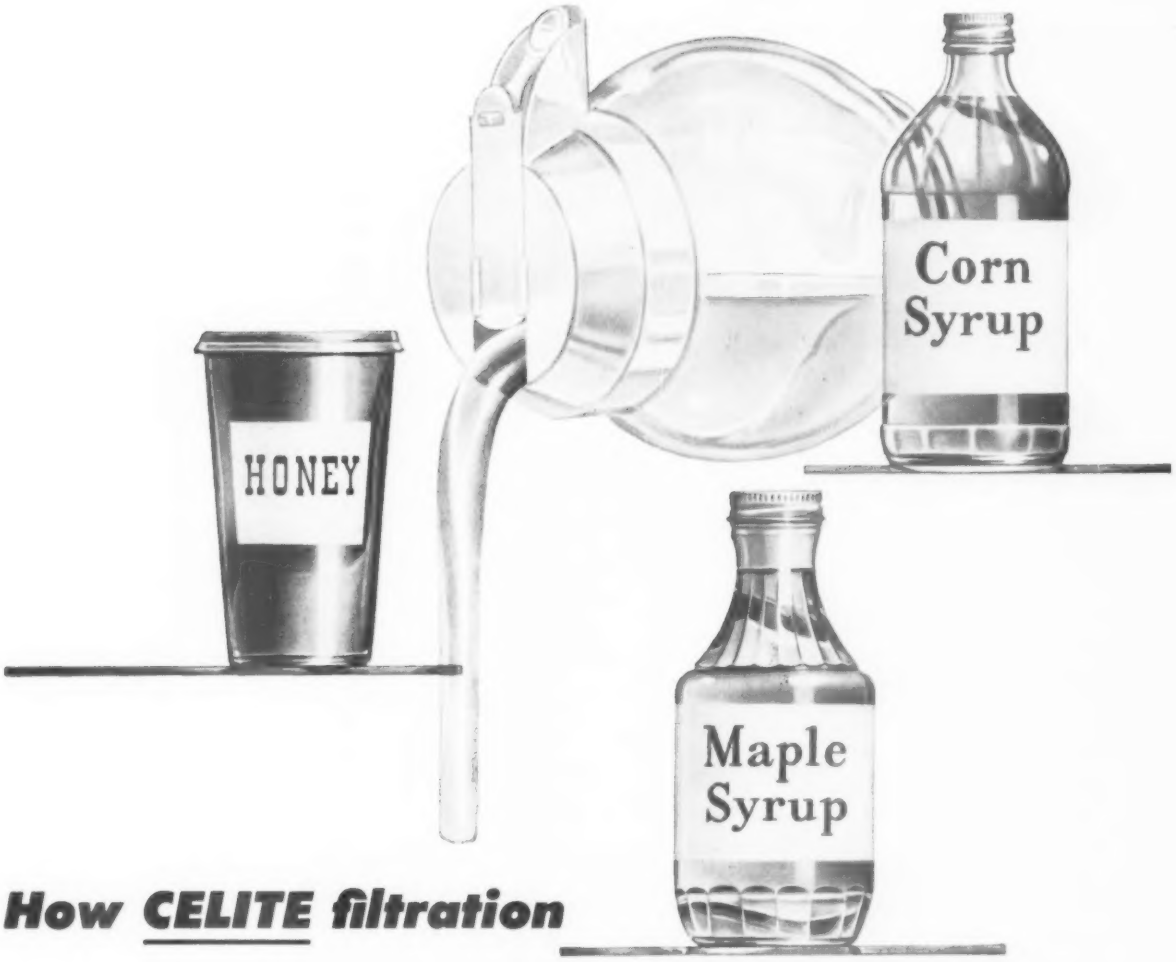
At the recent meeting of the Millers' National Federation in Chicago, Mr. Wm. J. Orchard, president of Wallace & Tiernan Process Company, Belleville, N. J., announced the development of *a continuous bread dough making process* called the "John C. Baker Dō-Maker Process." The process, developed by Dr. John C. Baker, director of research for Wallace & Tiernan Industries, and the company's technical staff, has passed the pilot stage and will be installed in six unnamed bakeries on the Eastern seaboard this summer. After satisfactory plant scale commercial operation, the process will be made available to the baking industry. The unit now installed at company headquarters is capable of producing 60 one-pound loaves of bread per minute using commercial bread formulae, and occupies 100 square feet of floor space. New techniques noted are prefermentation of a yeast broth prior to incorporation with the other ingredients. Shortening and oxidizing agents are fed as liquids. Ingredients pass through feeding devices into premix chamber, and after thorough mixing the product is metered to the developer from which it passes to the divider and into the pans, accurately controlled, exact in weight, and untouched by human hands. From the flour feeders to the conventional pan proof box requires from two to three minutes. The process reportedly eliminates the use of conventional mixers, dividers, rounders, moulders, overhead proofers, dough troughs, and fermentation rooms. Also eliminated are dusting flour, divider oil, and trough grease. A fully automatic bakery may now be operated from a central control panel. All ingredients used are permissible under the Federal Standards of Identity of Bread and will require no further hearing or approval of Federal Agencies, according to the company.

A fast-paced little news digest published by the Fatty Acid Division of the Association of American Soap & Glycerine Producers, Inc., 295 Madison Ave., New York 17, N. Y., presents news shorts of interest regarding plants, processes, products, product applications, chemistry, and research. Among items covered are "concurrent production of fatty alcohols and sodium cyanate," "odorless, stable, and digestible fish oils," "air entraining agents in concrete construction work," "flavoring with pelargonates," "catalysis of unsaturated fat oxidation," "nutritive value of glycerides," and a new "oxidation inhibitor."

Continuing the expansion of its plant facilities, The Givaudan Corporation has opened two additional floors to a new building which was erected in 1951. In announcing the addition to the plant, Mr. E. R. Durrer, president, stated that the new facilities—including plant executive offices, engineering department offices, and research laboratories—greatly improve the operation of the factory and facilitate the services which the Givaudan organization is giving to its customers. Largest of the ten laboratories is the one used exclusively in the Analytical Department. The modern facilities in this laboratory are devoted to maintaining a chemical control of all material entering and leaving the factory. All finished products are subjected not only to olfactory examination but also to chemical analysis—which guarantees products of uniform chemical and olfactory quality. Also included in the expanded facilities are several laboratories devoted to scientific research; a laboratory used exclusively for bacteriological research and sales service problems of a biological nature; a new staff library containing several thousand scientific volumes, journals, trade papers, a patent file, and a microfilm reader; and a large stock room.

Givaudan also announces publication of three new technical bulletins. Technical Bulletin 53-1, "FLAVORS FOR DRINKS," contains seven pages of useful information for the manufacturer of flavored drinks, and recommends formulations for the preparation of syrups, complete flavor bases, and drink concentrates (or nectars). With the formulas given for complete beverage bases, bottler's recommendations for use are also indicated. Bulletin 53-2, "FLAVORS FOR ICE CREAM," (four pages)

(Continued on page 36)



How CELITE filtration produces sparkling-clear syrups

YOU can secure syrups with high brilliancy and sparkling clarity, because Celite* Filtration removes *all* suspended impurities. Even highly viscous liquids may be filtered with exceptional efficiency. The result is a product with more eye appeal . . . more "buy" appeal . . . and frequently a product made at lower cost.

Celite aids almost every step of your clarification processes. It cuts down the need for reprocessing, helps decolorizing, minimizes inversion losses. If you employ char filters, Celite reduces the load on this equipment. Where vegetable carbon is used, Celite assures complete removal after treatment.

Longer filtration cycles at fast flow rates are possible with Celite. Downtime is less frequent, filters may be cleaned more quickly, and your filter cloths have longer life.

All these advantages result from the inherent properties of Celite itself. Carefully processed from the purest deposits of diatomaceous earth, Celite is a lightweight, porous powder. It is chemically inert, insoluble, and specially treated so that it imparts no foreign flavor to organic products.

Celite has long been used to improve product quality and speed the processing of sugar, fruits and juices, beer and wine, many other beverages and foods. It will pay you to investigate the many advantages of Celite Filtration for your own products. A Celite Field Engineer will gladly consult with you. For his services—at no obligation to you—simply write Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay St., Toronto 1, Ontario.

JM CELITE Johns-Manville

*Reg. U. S. Pat. Off.

JOHNS MANVILLE JM PRODUCTS

Johns-Manville CELITE FILTER AND PRESSING AIDS

hu-mec'tant

A substance having affinity for water, with stabilizing action on the water content of an article.

Example: GLYCERINE!

When product moisture content must be kept constant in spite of fluctuations in humidity, leading manufacturers of foods, drugs and cosmetics rely on U.S.P. Glycerine. For many years Glycerine has been the humectant in such famous products as Chase "Pep-R-Mints" and Pine Brothers Cough Drops.

If you're developing a new product that will contain a humectant, be sure to check Glycerine.

'Cereal Bar'

For example, the U. S. Army Quartermaster Corps recently developed a compressed, premixed cereal for ration kits and survival rations. They chose U.S.P. Glycerine as the edible binder because it enhances sweetening, while restraining stickiness, spoilage, and mold growth, and—most important of all—because it is non-toxic.

Balance of Properties

You can see that humectant action is only a small part of the Glycerine story. *Versatile* Glycerine can also serve as—

emollient	**lubricant**
solvent	**demulcent**
plasticizer	**suspending agent**
sweetener	**chemical intermediate**

Booklets on the application of Glycerine in the food, drug and cosmetic, protective coatings, and textile fields are available. For your copy, write Glycerine Producers' Association, 295 Madison Avenue, New York 17, N. Y.

Nothing takes the place of Glycerine

Food Industry Topics

(Continued from page 34)

suggests various formulations for use in preparing ice cream flavors and also gives formulae for four basic solutions used in preparing the suggested finished ice cream flavors. Bulletin 53-3, "FLAVORS FOR CONFECTIONS," presents four pages of basic information on candy making, and lists specific flavors recommended for use in three types of confections, namely: Hard Candies; Covered Fondants, Cream Centers and Fudge; and Pectin Jellies and Other Gum Candies. Concentrations and other production data are included. These technical bulletins are available upon request to Givaudan Flavors, Inc., 330 W. 42nd St., New York 36, N. Y.

◆ ◆ ◆

Fritzsche Brothers, Inc., New York City, 82-year-old essential oil and chemical firm, has announced the election of Mr. Frederick H. Leonhardt, former president, to the newly created office of chairman of the board. Mr. Leonhardt, in his sixtieth year of service with the company, has been president since 1934 and has led the firm through its period of greatest expansion. Succeeding to the presidency is Mr. John H. Montgomery, first vice president, who has been with the company since 1925 and has for many years worked closely with Mr. Leonhardt in the execution of his policies. Other officers elected include: Mr. H. Paul Wesemann, first vice president; Mr. John L. Cassullo, treasurer; Mr. D. A. Neary, secretary; Mr. Ernest S. Guenther, second vice president; Mr. Fred H. Leonhardt, Jr., third vice president; Mr. Joseph A. Huisking, fourth vice president; Mr. G. A. Wohlfort, assistant treasurer; Mr. Arthur Hemminger, assistant secretary; and Mr. Ellis Merkl, comptroller.

◆ ◆ ◆

Nine new organic chemicals, including 1-Phenyldodecane, have just been added to the list of more than 3,500 organic chemicals offered by Distillation Products Industries, Eastman Organic Chemicals Dept., Rochester 3, N. Y. 1-Phenyldodecane, the company feels, may possibly become the point of departure for an idea of which it is said later, "Why didn't I think of that?" Its structure—a hammer with a benzene ring for a head and a saturated C_{12} handle—appears to offer interesting possibilities, states the company. Physically, the chemical is a slightly viscous liquid that melts at minus 5° to minus 3° C., and boils at 179° to 180° C. when pressure is reduced to 13 mm. Hg. Density runs about 0.86. The company is prepared to meet requests for small quantities of the chemical at present, and will be happy to consider requests for larger-than-laboratory quantities. Following is a complete list of the new chemicals offered by Eastman: a Chloro-N-ethylacetanilide; Dehydrocholic Acid; Di-n-butyl Fumarate; Di-iso-butyl Fumarate; Di-iso-butyl Phthalate; a,a'-Dichloro-p-xylene; Isonicotinic Acid; l-Menthol (Synthetic); and 1-Phenyldodecane.

Eastman also announces the first supplement to the current published list (No. 38) of its organic chemicals. The supplement lists 40 additions to the catalog, show-

ing the name of the chemical, its melting or boiling point, structural formula, molecular weight, and price according to quantity. It also includes removals and price changes. Write to the above address.

• • •

Big doings at Florasynth Laboratories, Inc., both plant-wise and product-wise. From Mr. William Lakritz, company president, comes word of plans for substantial enlargement of the firm's Eastern plant and facilities. The new home of the Florasynth New York plant will be the tremendous former Borden Company building and grounds at 900 Van Nest Ave., New York City, in the upper section of the Bronx. The acquisition gives the Florasynth operations an additional area of 70,000 square feet of production, shipping, and office facilities under the most modern conditions. Included in the new three-story building will be large new research and development laboratories. For the present, until necessary installations are completed, and in order to continue its uninterrupted services and supply to its customers, the company will maintain production facili-

ties at both the new plant and the present plant, located at 1513-1533 Olmstead Ave., New York City. According to the schedule outlined by Mr. Lakritz, the Executive and General offices will be moved into the new quarters by June 1953, and heavy and complete production will begin the early part of 1954.

(Continued on page 38)

FUTURE DATES FOR FOOD TECHNOLOGISTS

1953

July 14-25	Sixth Internation Congress on Radiobiology, Copenhagen
July 20-24	Conference on Microbiological Deterioration. Gordon Research Conference (American Association for the Advancement of Science) New Hampton School, New Hampton, New Hampshire.
July 27-31	Conference on Statistics in Chemistry. Gordon Research Conference (American Association for the Advancement of Science) New Hampton School, New Hampton, New Hampshire.
August 10-14	Conference on Food and Nutrition, Gordon Research Conference (American Association for the Advancement of Science) Colby Junior College, New London, New Hampshire.
September 6-9	American Institute of Biological Sciences, University of Wisconsin, Madison
September 6-11	One hundred and twenty-fourth Meeting of the American Chemical Society, Chicago, Illinois
September 13-16	American Institute of Chemical Engineers, San Francisco, California
October 12-14	Fifteenth Annual Forum of the Packaging Institute, New York City
June 27 to July 1, 1954	**Fourteenth Annual Meeting of the Institute of Food Technologists, Los Angeles, California**

(Information concerning future dates of national and international meetings, conventions and exhibits of interest to food technologists should be sent to the editorial office.)

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The effectiveness, ease of use and economy of this new salt will more than justify its test in your operation. Samples are available upon request. Send for yours today!

Write to Technical Director, Diamond Crystal Salt Co., St. Clair, Michigan.

DIAMOND CRYSTAL SALT with Antioxidant

Food Industry Topics

(Continued from page 37)

In the product field, Florasynth announces that two-and-one-half years of research work has culminated in development of a new line of entrapped powdered flavors for food processors, for general use in dry mixes such as gelatine desserts, puddings, cake mixes, dry spice mixes, and other products of that type. These new entrapped flavors—in which the flavoring material is entrapped in a combination vegetable gum and polyhydric acid—are manufactured in all flavors, including spices, and are designed to (1) prevent oxidation, evaporation, and any other chemical reactions that can take place between the other materials of the mix and the flavoring material, (2) give a substantially higher shelf life than the normal liquids confer, (3) provide a higher degree of dispersibility within the mix, (4) be instantly dispersible in cold water, thus releasing the flavor for immediate use in various products in dry mixes where moisture is added to make up the finished product. According to the company, recently completed shelf-life studies show remarkable results as compared to flavoring material in dry mixes that is added in liquid form. Another unusual qualification of the product, says the company, is that it can be manufactured at approximately the same cost as the presently-used liquid flavoring material. Furthermore, the mesh of the product can be controlled, thereby preventing sifting for general dry mix use. Samples are available

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(Continued from page 38)

upon request. If there are special problems involved in a particular dry mix, the product can be tailored to fit various problems in the individual manufacturer's operation.

◆ ◆ ◆

Food producers—take notice! *Water can be frozen to any selected degree between 32° F. and zero!* The technique has been developed by physicist Dr. Carl Berger through icing experiments conducted under contract with the U. S. Air Force at the Commonwealth Engineering Company of Ohio, 1771 Springfield St., Dayton, Ohio. Results should reportedly have wide application in military and commercial fields—from ice formation on airplanes to refreezing frozen foods. According to Dr. Berger, the surface and type of material—either metallic or nonmetallic—on which the water is frozen help control the formation of ice. Moreover, ice crystals vary in size and shape, producing different effects on material both externally and internally. According to Dr. Berger, the problem of rupture of fruit cells by ice crystals in refrozen orange juice is "pretty well licked." "If we get a set of general rules," he continues, "on how water freezes at certain temperatures and what crystallines are formed, we can apply the rules to all sorts of practical problems and know how to get ice off all shapes and types of materials." Pointing out that the low temperature field is vital to food producers because food processed at low temperatures keeps all of its nutrients, Dr. Berger expressed the hope that the program will continue and branch into new fields. He believes the chances of considerably lowering practical freezing point temperatures are very good.

◆ ◆ ◆

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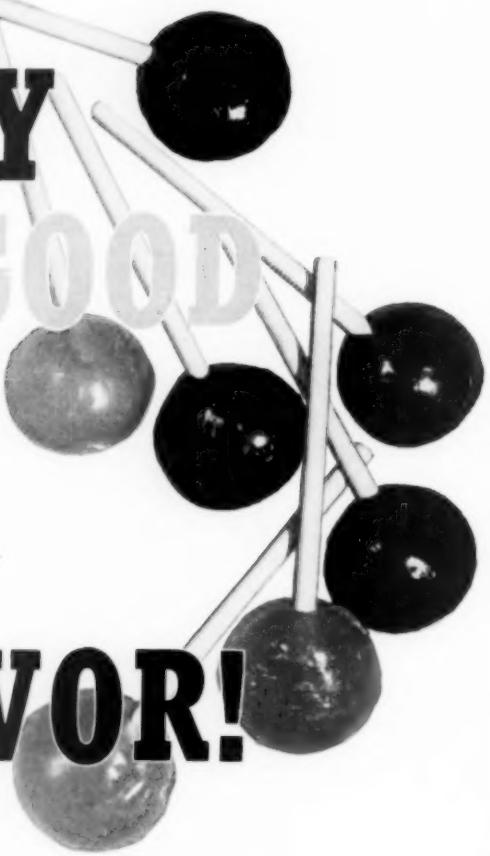

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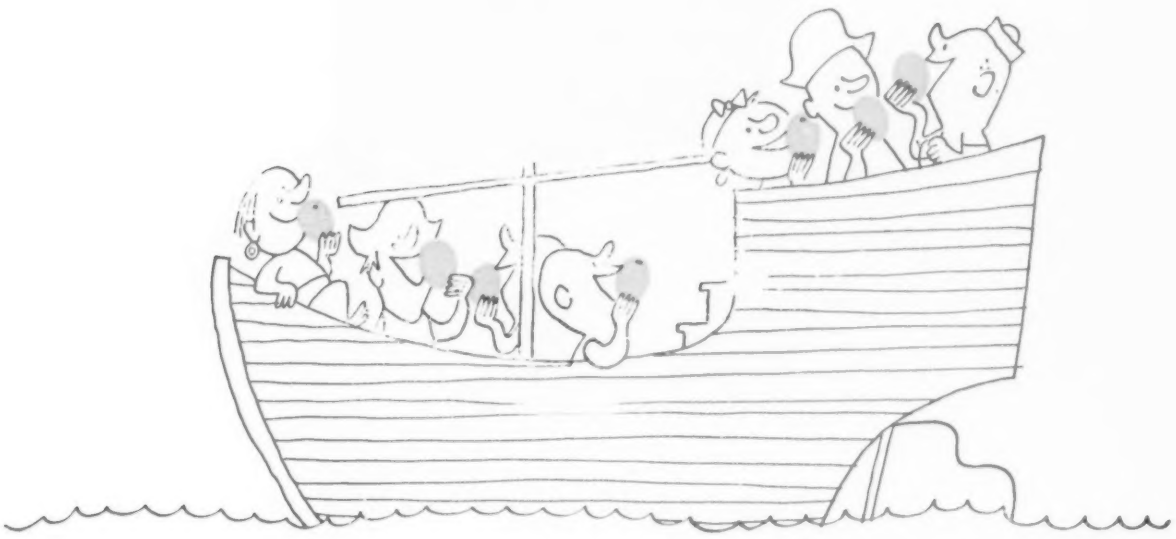

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NOTE: Full technical report published in November 1952 FOOD TECHNOLOGY Magazine "The Use of Monosodium Glutamate in Frozen Foods" by Carl B. Norton, Donald K. Tressler, and Lillian D. Farkas.

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